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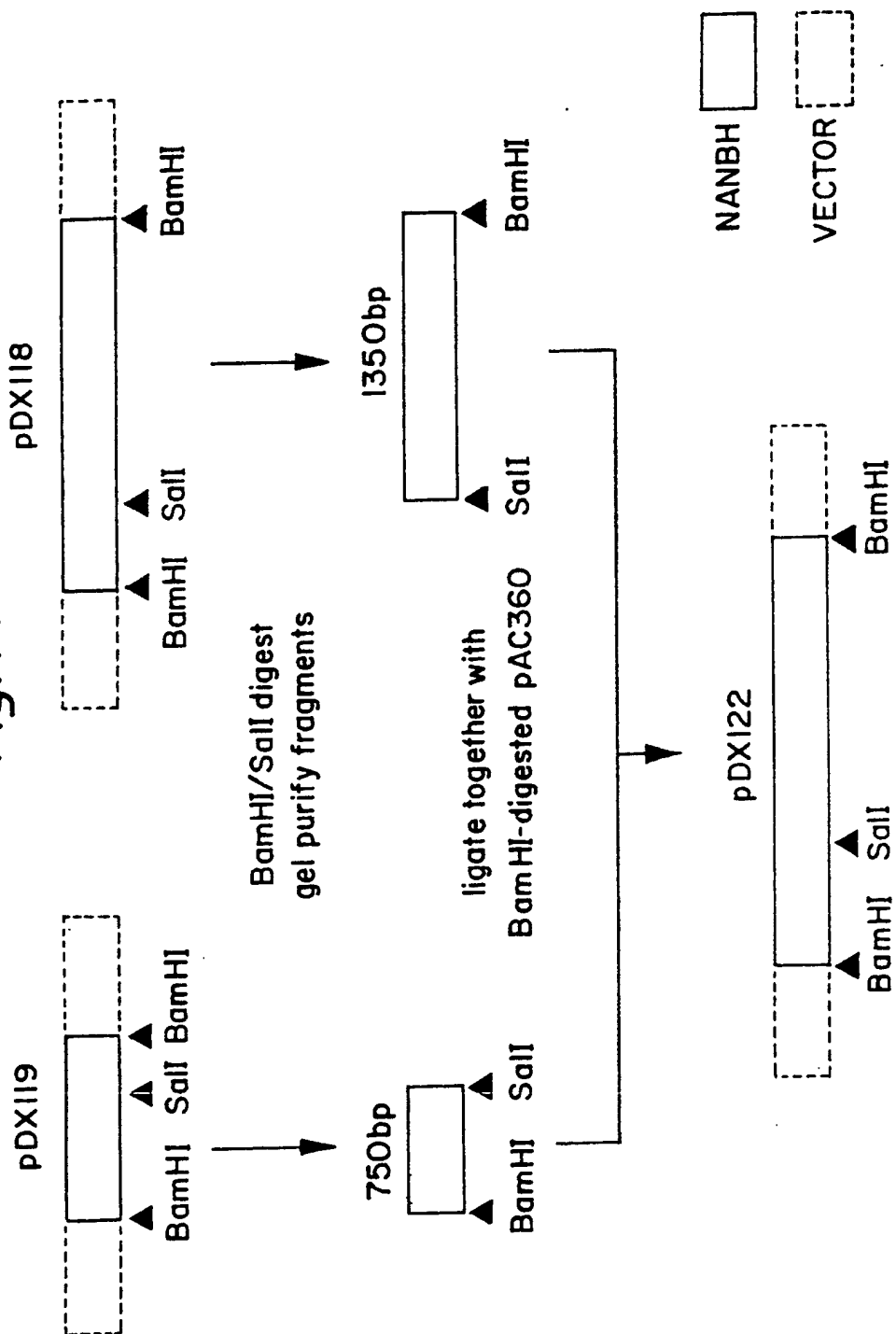
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(54) Post-transfusional non-A non-B hepatitis viral polypeptides

(57) Post-transfusional non-A non-B hepatitis viral polypeptide, DNA sequences encoding such viral polypeptide, expression vectors containing such DNA sequences, and hosts transformed by such expression vectors, which may be used in diagnostic assays and vaccine formulations, are described.

Fig. 1.



DX119

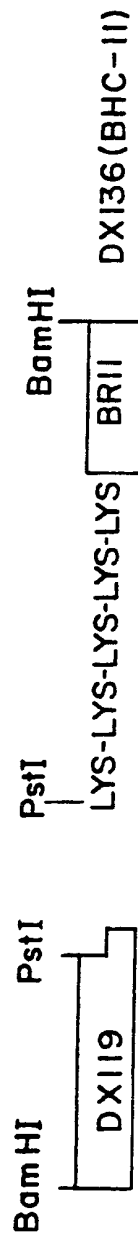
BamHI PstI

DX143 (BHC-10)

PstI BamHI BR11

**Linker: ValSerAlaGluPheArg**

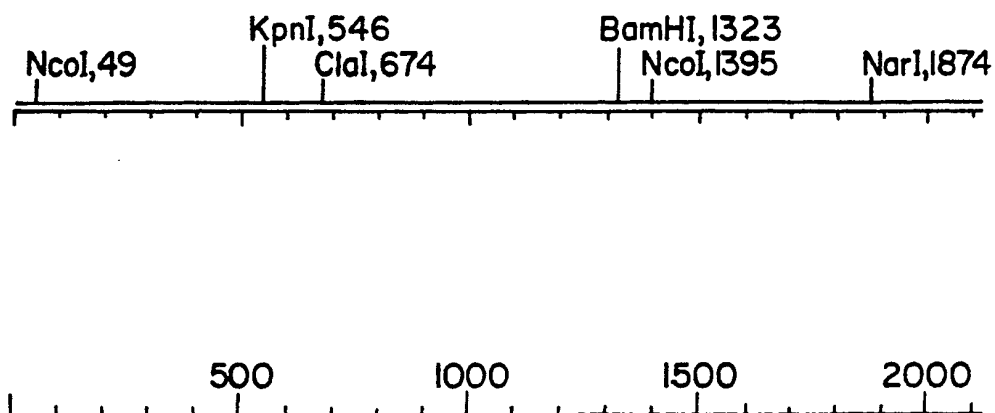
**lambda**



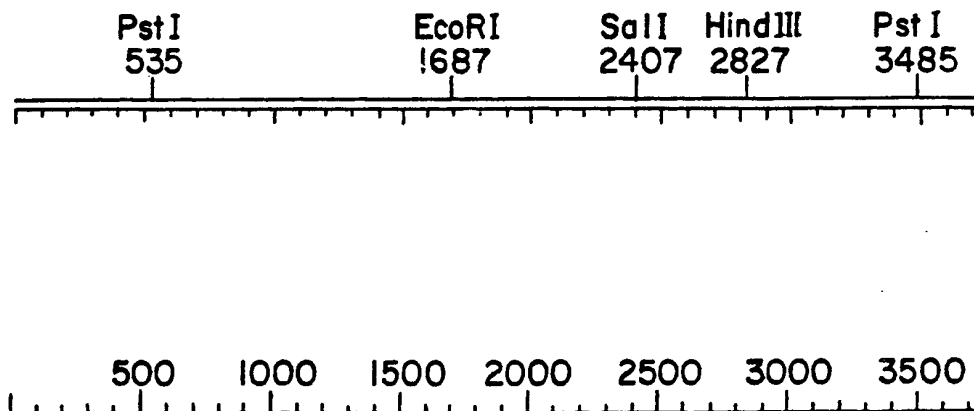
Linker: ValLysLysLysLysLys

*Fig. 3.*

SEQ. ID No. 21 (2116 bps)



SEQ. ID No. 22 (3756 bps)



VIRAL AGENT

The present invention relates to the isolation and characterisation of the viral agent responsible for post-transfusional non-A non-B hepatitis (PT-NANBH) and in particular to PT-NANBH viral polypeptides, DNA sequences encoding such viral polypeptides, expression vectors containing such DNA sequences, and host cells transformed by such expression vectors. The present invention also relates to the use of a DNA sequence in a nucleic acid hybridisation assay for the diagnosis of PT-NANBH. The present invention further relates to the use of PT-NANBH viral polypeptides or polyclonal or monoclonal antibodies against such polypeptides in an immunoassay for the diagnosis of PT-NANBH or in a vaccine for its prevention.

Non-A non-B hepatitis (NANBH) is by definition a diagnosis of exclusion and has generally been employed to describe cases of viral hepatitis infection in human beings that are not due to hepatitis A or B viruses. In the majority of such cases, the cause of the infection has not been identified although, on clinical and epidemiological grounds, a number of agents have been thought to be responsible as reviewed in Shih et al (Prog. Liver Dis., 1986, 8, 433-452). In the USA alone, up to 10% of blood transfusions can result in NANBH which makes it a significant problem. Even for PT-NANBH there may be at least several viral agents responsible for the infection and over the years many claims have been made for the identification of the agent, none of which has been substantiated.

European Patent Application 88310922.5 purports to describe the isolation and characterisation of the aetiological agent responsible for PT-NANBH which is also referred to in the application as hepatitis C virus (HCV). A cDNA library was prepared from viral nucleic acid obtained from a chimpanzee infected with PT-NANBH and was screened using human antisera. A number of positive clones were isolated and sequenced. The resulting nucleic acid and amino acid sequence data, which are described in the application, represent approximately 70% of

the 10kb viral genome and are derived entirely from its 3'-end corresponding to the non-structural coding region.

The present inventors have now isolated and characterised PT-NANBH viral polypeptides by the cloning and expression of DNA sequences encoding such viral polypeptides. Surprisingly, the nucleic acid and amino acid sequence data both show considerable differences with the corresponding data reported in European Patent Application 88310922.5. Overall these differences amount to about 20% at the nucleic acid level and about 15% at the amino acid level but some regions of the sequences show even greater differences. The overall level of difference is much larger than would be expected for two isolates of the same virus even allowing for geographical factors, and is believed to be due to one of two possible reasons.

Firstly, the present inventors and those of the aforementioned European Patent Application used different sources for the nucleic acid used in the cDNA cloning. In particular, the European Patent Application describes the use of chimpanzee plasma as the source for the viral nucleic acid starting material, with the virus having been passaged through a chimpanzee on two occasions. PT-NANBH is of course an human disease and passaging the virus through a foreign host, even if it is a close relative to humans, is likely to result in extensive mutation of the viral nucleic acid. Accordingly, the sequence data contained in European Patent Application 88310922.5 may not be truly representative of the actual viral agent responsible for PT-NANBH in humans. In contrast, the present inventors utilised viral nucleic acid from a human plasma source as the starting material for cDNA cloning. The sequence data thus obtained is much more likely to correspond to the native nucleic acid and amino acid sequences of PT-NANBH.

Secondly, it may be that the viral agent exists as more than one subtype and the sequence data described in the European Patent Application and that elucidated by the present inventors correspond to

separate and distinct subtypes of the same viral agent. Alternatively, it may be that the level of difference between the two sets of sequence data is due to a combination of these two factors.

The present invention provides a PT-NANBH viral polypeptide comprising an antigen having an amino acid sequence that is at least 90% homologous with the amino acid sequence set forth in SEQ ID NO: 3,4,5, 18,19,20,21 or 22, or is an antigenic fragment thereof.

SEQ ID NO : 3,4,5,18,19,20,21 or 22 set forth the amino acid sequence as deduced from the nucleic acid sequence. Preferably, the amino acid sequence is at least 95% or even 98% homologous with the amino acid sequence set forth in SEQ ID NO : 3,4,5,18,19,20,21 or 22. Optionally, the antigen may be fused to an heterologous polypeptide.

Two or more antigens may optionally be used together either in combination or fused as a single polypeptide. The use of two or more antigens in this way in a diagnostic assay provides more reliable results in the use of the assay in blood screening for PT-NANBH virus. Preferably, one antigen is obtained from the structural coding region (the 5'-end) and one other antigen is obtained from the non-structural coding region (the 3'-end). It is particularly preferred that the antigens are fused together as a recombinant polypeptide. This latter approach offers a number of advantages in that the individual antigens can be combined in a fixed, pre-determined ratio (usually equimolar) and only a single polypeptide needs to be produced, purified and characterised.

An antigenic fragment of an antigen having an amino acid sequence that is at least 90% homologous with that set forth in SEQ ID NO : 3,4,5, 18,19,20,21 or 22 preferably contains a minimum of five, six, seven, eight, nine or ten, fifteen, twenty, thirty, forty or fifty amino acids. The antigenic sites of such antigens may be identified using standard procedures. These may involve fragmentation of the polypeptide itself using proteolytic enzymes or chemical agents and

then determining the ability of each fragment to bind to antibodies or to provoke an immune response when inoculated into an animal or suitable in vitro model system (Strohmaier et al, J.Gen.Virol., 1982, 59, 205-306). Alternatively, the DNA encoding the polypeptide may be fragmented by restriction enzyme digestion or other well-known techniques and then introduced into an expression system to produce fragments (optionally fused to a polypeptide usually of bacterial origin). The resulting fragments are assessed as described previously (Spence et al, J.Gen.Virol., 1989, 70, 2843-51; Smith et al, Gene, 1984, 29, 263-9). Another approach is to synthesise chemically short peptide fragments (3-20 amino acids long; conventionally 6 amino acids long) which cover the entire sequence of the full-length polypeptide with each peptide overlapping the adjacent peptide. (This overlap can be from 1-10 amino acids but ideally is n-1 amino acids where n is the length of the peptide; Geysen et al, Proc. Natl. Acad. Sci., 1984, 81, 3998-4002). Each peptide is then assessed as described previously except that the peptide is usually first coupled to some carrier molecule to facilitate the induction of an immune response. Finally, there are predictive methods which involve analysis of the sequence for particular features, e.g. hydrophilicity, thought to be associated with immunologically important sites (Hopp and Woods, Proc. Natl. Acad. Sci., 1981, 78, 3824-8; Berzofsky, Science, 1985, 229, 932-40). These predictions may then be tested using the recombinant polypeptide or peptide approaches described previously.

Preferably, the viral polypeptide is provided in a pure form, i.e. greater than 90% or even 95% purity.

The PT-NANBH viral polypeptide of the present invention may be obtained using an amino acid synthesiser, if it is an antigen having no more than about thirty residues, or by recombinant DNA technology.

The present invention also provides a DNA sequence encoding a PT-NANBH viral polypeptide as herein defined.



The DNA sequence of the present invention may be synthetic or cloned. Preferably, the DNA sequence is as set forth in SEQ ID NO : 3,4,5,18, 19,20,21 or 22.

To obtain a PT-NANBH viral polypeptide comprising multiple antigens, it is preferred to fuse the individual coding sequences into a single open reading frame. The fusion should of course be carried out in such a manner that the antigenic activity of each antigen is not significantly compromised by its position relative to another antigen. Particular regard should of course be had for the nature of the sequences at the actual junction between the antigens. The methods by which such single polypeptides can be obtained are well known in the art.

The present invention also provides an expression vector containing a DNA sequence, as herein defined, and being capable in an appropriate host of expressing the DNA sequence to produce a PT-NANBH viral polypeptide.

The expression vector normally contains control elements of DNA that effect expression of the DNA sequence in an appropriate host. These elements may vary according to the host but usually include a promoter, ribosome binding site, translational start and stop sites, and a transcriptional termination site. Examples of such vectors include plasmids and viruses. Expression vectors of the present invention encompass both extrachromosomal vectors and vectors that are integrated into the host cell's chromosome. For use in E.coli, the expression vector may contain the DNA sequence of the present invention optionally as a fusion linked to either the 5'- or 3'-end of the DNA sequence encoding, for example,  $\beta$ -galactosidase or to the 3'-end of the DNA sequence encoding, for example, the trp E gene. For use in the insect baculovirus (AcNPV) system, the DNA sequence is optionally fused to the polyhedrin coding sequence.

The present invention also provides a host cell transformed with an expression vector as herein defined.

Examples of host cells of use with the present invention include prokaryotic and eukaryotic cells, such as bacterial, yeast, mammalian and insect cells. Particular examples of such cells are E.coli, S.cerevisiae, P.pastoris, Chinese hamster ovary and mouse cells, and Spodoptera frugiperda and Tricoplusia ni. The choice of host cell may depend on a number of factors but, if post-translational modification of the PT-NANBH viral polypeptide is important, then an eukaryotic host would be preferred.

The present invention also provides a process for preparing PT-NANBH viral polypeptide which comprises cloning or synthesising a DNA sequence encoding PT-NANBH viral polypeptide, as herein defined, inserting the DNA sequence into an expression vector such that it is capable in an appropriate host of being expressed, transforming an host cell with the expression vector, culturing the transformed host cell, and isolating the viral polypeptide.

The cloning of the DNA sequence may be carried out using standard procedures known in the art. However, it is particularly advantageous in such procedures to employ the sequence data disclosed herein so as to facilitate the identification and isolation of the desired cloned DNA sequences. Preferably, the RNA is isolated by pelleting the virus from plasma of infected humans identified by implication in the transmission of PT-NANBH. The isolated RNA is reverse transcribed into cDNA using either random or oligo-dT priming. Optionally, the RNA may be subjected to a pre-treatment step to remove any secondary structure which may interfere with cDNA synthesis, for example, by heating or reaction with methyl mercuric hydroxide. The cDNA is usually modified by addition of linkers followed by digestion with a restriction enzyme. It is then inserted into a cloning vector, such as pBR322 or a derivative thereof or the lambda vectors gt10 and gt11 (Huynh et al, DNA Cloning, 1985, Vol 1: A Practical Approach, Oxford,

IRC Press) packaged into virions as appropriate, and the resulting recombinant DNA molecules used to transform E.coli and thus generate the desired library.

The library may be screened using a standard screening strategy. If the library is an expression library, it may be screened using an immunological method with antisera obtained from the same plasma source as the RNA starting material and also with antisera from additional human sources expected to be positive for antibodies against PT-NANBH. Since human antisera usually contains antibodies against E.coli which may give rise to high background during screening, it is preferable first to treat the antisera with untransformed E.coli lysate so as to remove any such antibodies. It is advantageous to employ a negative control using antisera from accredited human donors, i.e. human donors who have been repeatedly tested and found not to have antibodies against viral hepatitis. An alternative screening strategy would be to employ as hybridisation probes one or more labelled oligonucleotides. The use of oligonucleotides in screening a cDNA library is generally simpler and more reliable than screening with antisera. The oligonucleotides are preferably synthesised using the DNA sequence information disclosed herein. One or more additional rounds of screening of one kind or another may be carried out to characterise and identify positive clones.

Having identified a first positive clone, the library may be rescreened for additional positive clones using the first clone as an hybridization probe. Alternatively or additionally, further libraries may be prepared and these may be screened using immunoscreens or hybridisation probes. In this way, further DNA sequences may be obtained.

Alternatively, the DNA sequence encoding PT-NANBH viral polypeptide may be synthesised using standard procedures and this may be preferred

to cloning the DNA in some circumstances (Gait, Oligonucleotide Synthesis: A Practical Approach, 1984, Oxford, IRL Press).

Thus cloned or synthesised, the desired DNA sequence may be inserted into an expression vector using known and standard techniques. The expression vector is normally cut using restriction enzymes and the DNA sequence inserted using blunt-end or staggered-end ligation. The cut is usually made at a restriction site in a convenient position in the expression vector such that, once inserted, the DNA sequence is under the control of the functional elements of DNA that effect its expression.

Transformation of an host cell may be carried out using standard techniques. Some phenotypic marker is usually employed to distinguish between the transformants that have successfully taken up the expression vector and those that have not. Culturing of the transformed host cell and isolation of the PT-NANBH viral polypeptide may also be carried out using standard techniques.

Antibody specific to a PT-NANBH viral polypeptide of the present invention can be raised using the polypeptide. The antibody may be polyclonal or monoclonal. The antibody may be used in quality control testing of batches of PT-NANBH viral polypeptide; purification of a PT-NANBH viral polypeptide or viral lysate; epitope mapping; when labelled, as a conjugate in a competitive type assay, for antibody detection; and in antigen detection assays.

Polyclonal antibody against a PT-NANBH viral polypeptide of the present invention may be obtained by injecting a PT-NANBH viral polypeptide, optionally coupled to a carrier to promote an immune response, into a mammalian host, such as a mouse, rat, sheep or rabbit, and recovering the antibody thus produced. The PT-NANBH viral polypeptide is generally administered in the form of an injectable formulation in which the polypeptide is admixed with a physiologically acceptable diluent. Adjuvants, such as Freund's complete adjuvant

(FCA) or Freund's incomplete adjuvant (FIA), may be included in the formulation. The formulation is normally injected into the host over a suitable period of time, plasma samples being taken at appropriate intervals for assay for anti-PT-NANBH viral antibody. When an appropriate level of activity is obtained, the host is bled. Antibody is then extracted and purified from the blood plasma using standard procedures, for example, by protein A or ion-exchange chromatography.

Monoclonal antibody against a PT-NANBH viral polypeptide of the present invention may be obtained by fusing cells of an immortalising cell line with cells which produce antibody against the viral polypeptide, and culturing the fused immortalised cell line. Typically, a non-human mammalian host, such as a mouse or rat, is inoculated with the viral polypeptide. After sufficient time has elapsed for the host to mount an antibody response, antibody producing cells, such as the splenocytes, are removed. Cells of an immortalising cell line, such as a mouse or rat myeloma cell line, are fused with the antibody producing cells and the resulting fusions screened to identify a cell line, such as a hybridoma, that secretes the desired monoclonal antibody. The fused cell line may be cultured and the monoclonal antibody purified from the culture media in a similar manner to the purification of polyclonal antibody.

Diagnostic assays based upon the present invention may be used to determine the presence or absence of PT-NANBH infection. They may also be used to monitor treatment of such infection, for example in interferon therapy.

In an assay for the diagnosis of viral infection, there are basically three distinct approaches that can be adopted involving the detection of viral nucleic acid, viral antigen or viral antibody. Viral nucleic acid is generally regarded as the best indicator of the presence of the virus itself and would identify materials likely to be infectious. However, the detection of nucleic acid is not usually as straightforward as the detection of antigens or antibodies since the

level of target can be very low. Viral antigen is used as a marker for the presence of virus and as an indicator of infectivity. Depending upon the virus, the amount of antigen present in a sample can be very low and difficult to detect. Antibody detection is relatively straightforward because, in effect, the host immune system is amplifying the response to an infection by producing large amounts of circulating antibody. The nature of the antibody response can often be clinically useful, for example IgM rather than IgG class antibodies are indicative of a recent infection, or the response to a particular viral antigen may be associated with clearance of the virus. Thus the exact approach adopted for the diagnosis of a viral infection depends upon the particular circumstances and the information sought. In the case of PT-NANBH, a diagnostic assay may embody any one of these three approaches.

In an assay for the diagnosis of PT-NANBH involving detection of viral nucleic acid, the method may comprise hybridising viral RNA present in a test sample, or cDNA synthesised from such viral RNA, with a DNA sequence corresponding to the nucleotide sequence of SEQ ID NO : 3,4,5,18,19,20,21 or 22 and screening the resulting nucleic acid hybrids to identify any PT-NANBH viral nucleic acid. The application of this method is usually restricted to a test sample of an appropriate tissue, such as a liver biopsy, in which the viral RNA is likely to be present at a high level. The DNA sequence corresponding to the nucleotide sequence of SEQ ID NO : 3,4,5,18,19,20,21 or 22 may take the form of an oligonucleotide or a cDNA sequence optionally contained within a plasmid. Screening of the nucleic acid hybrids is preferably carried out by using a labelled DNA sequence. One or more additional rounds of screening of one kind or another may be carried out to characterise further the hybrids and thus identify any PT-NANBH viral nucleic acid. The steps of hybridisation and screening are carried out in accordance with procedures known in the art.

Because of the limited application of this method in assaying for viral nucleic acid, a preferred and more convenient method comprises

synthesising cDNA from viral RNA present in a test sample, amplifying a preselected DNA sequence corresponding to a subsequence of the nucleotide sequence of SEQ ID NO : 3,4,5,18,19,20,21 or 22, and identifying the preselected DNA sequence. The test sample may be of any appropriate tissue or physiological fluid and is preferably concentrated for any viral RNA present. Examples of an appropriate tissue include a liver biopsy. Examples of an appropriate physiological fluid include urine, plasma, blood, serum, semen, tears, saliva or cerebrospinal fluid. Preferred examples are serum and plasma.

Synthesis of the cDNA is normally carried out by primed reverse transcription using random, defined or oligo-dT primers. Advantageously, the primer is an oligonucleotide corresponding to the nucleotide sequence of SEQ ID NO : 3,4,5,18,19,20,21 or 22 and designed to enrich for cDNA containing the preselected sequence.

Amplification of the preselected DNA sequence is preferably carried out using the polymerase chain reaction (PCR) technique (Saiki et al., Science, 1985, 230, 1350-4). In this technique, a pair of oligonucleotide primers is employed one of which corresponds to a portion of the nucleotide sequence of SEQ ID NO : 3,4,5,18,19,20,21 or 22 and the other of which is located to the 3' side of the first and corresponds to a portion of the complementary sequence, the pair defining between them the preselected DNA sequence. The oligonucleotides are usually at least 15, optimally 20 to 26, bases long and, although a few mismatches can be tolerated by varying the reaction conditions, the 3'-end of the oligonucleotides should be perfectly complementary so as to prime effectively. The distance between the 3'-ends of the oligonucleotides may be from about 100 to about 2000 bases. Conveniently, one of the pair of oligonucleotides that is used in this technique is also used to prime cDNA synthesis. The PCR technique itself is carried out on the cDNA in single stranded form using an enzyme, such as Taq polymerase, and an excess of the

oligonucleotide primers over 20-40 cycles in accordance with published protocols (Saiki et al, Science, 1988, 239, 487-491).

As a refinement of the technique, there may be several rounds of amplification, each round being primed by a different pair of oligonucleotides. Thus, after the first round of amplification, an internal pair of oligonucleotides defining a shorter DNA sequence (of, say, from 50 to 500 bases long) may be used for a second round of amplification. In this somewhat more reliable refinement, referred to as 'Nested PCR', it is of course the final amplified DNA sequence that constitutes the preselected sequence. (Kemp et al, Proc. Natl. Acad. Sci., 1989, 86(7), 2423-7 and Mullis et al, Methods in Enzymology, 1987, 155, 335-350).

Identification of the preselected DNA sequence may be carried out by analysis of the PCR products on an agarose gel. The presence of a band at the molecular weight calculated for the preselected sequence is a positive indicator of viral nucleic acid in the test sample. Alternative methods of identification include those based on Southern blotting, dot blotting, oligomer restriction and DNA sequencing.

The present invention also provides a test kit for the detection of PT-NANBH viral nucleic acid, which comprises

- i) a pair of oligonucleotide primers one of which corresponds to a portion of the nucleotide sequence of SEQ ID NO : 3,4,5,18,19,20,21 or 22 and the other of which is located to the 3' side of the first and corresponds to a portion of the complementary sequence, the pair defining between them a preselected DNA sequence;
- ii) a reverse transcriptase enzyme for the synthesis of cDNA from test sample RNA upstream of the primer corresponding to the complementary nucleotide sequence of SEQ ID NO : 3,4,5,18,19,20,21 or 22;



iii) an enzyme capable of amplifying the preselected DNA sequence; and optionally;

iv) washing solutions and reaction buffers.

Advantageously, the test kit also contains a positive control sample to facilitate in the identification of viral nucleic acid.

The characteristics of the primers and the enzymes are preferably as described above in connection with the PCR technique.

In an assay for the diagnosis of PT-NANBH involving detection of viral antigen or viral antibody, the method may comprise contacting a test sample with a PT-NANBH viral polypeptide of the present invention, or polyclonal or monoclonal antibody against the polypeptide, and determining whether there is any antigen-antibody binding contained within the test sample. For this purpose, a test kit may be provided comprising a PT-NANBH viral polypeptide, as defined herein, or a monoclonal or polyclonal antibody thereto, and means for determining whether there is any binding with antibody or antigen respectively contained in the test sample. The test sample may be taken from any of the appropriate tissues and physiological fluids mentioned above for the detection of viral nucleic acid. If a physiological fluid is obtained, it may optionally be concentrated for any viral antigen or antibody present.

A variety of assay formats may be employed. The PT-NANBH viral polypeptide can be used to capture selectively antibody against PT-NANBH from solution, to label selectively the antibody already captured, or both to capture and label the antibody. In addition, the viral polypeptide may be used in a variety of homogeneous assay formats in which the antibody reactive with the antigen is detected in solution with no separation of phases.

The types of assay in which the PT-NANBH viral polypeptide is used to capture antibody from solution involve immobilization of the polypeptide onto a solid surface. This surface should be capable of being washed in some way. Examples of suitable surfaces include polymers of various types (moulded into microtitre wells; beads; dipsticks of various types; aspiration tips; electrodes; and optical devices), particles (for example latex; stabilized red blood cells; bacterial or fungal cells; spores; gold or other metallic or metal-containing sols; and proteinaceous colloids) with the usual size of the particle being from 0.02 to 5 microns, membranes (for example of nitrocellulose; paper; cellulose acetate; and high porosity/high surface area membranes of an organic or inorganic material).

The attachment of the PT-NANBH viral polypeptide to the surface can be by passive adsorption from a solution of optimum composition which may include surfactants, solvents, salts and/or chaotropes; or by active chemical bonding. Active bonding may be through a variety of reactive or activatable functional groups which may be exposed on the surface (for example condensing agents; active acid esters, halides and anhydrides; amino, hydroxyl, or carboxyl groups; sulphhydryl groups; carbonyl groups; diazo groups; or unsaturated groups). Optionally, the active bonding may be through a protein (itself attached to the surface passively or through active bonding), such as albumin or casein, to which the viral polypeptide may be chemically bonded by any of a variety of methods. The use of a protein in this way may confer advantages because of isoelectric point, charge, hydrophilicity or other physico-chemical property. The viral polypeptide may also be attached to the surface (usually but not necessarily a membrane) following electrophoretic separation of a reaction mixture, such as immune precipitation.

After contacting (reacting) the surface bearing the PT-NANBH viral polypeptide with a test sample, allowing time for reaction, and, where necessary, removing the excess of the sample by any of a variety of means, (such as washing, centrifugation, filtration, magnetism or

capillary action) the captured antibody is detected by any means which will give a detectable signal. For example, this may be achieved by use of a labelled molecule or particle as described above which will react with the captured antibody (for example protein A or protein G and the like; anti-species or anti-immunoglobulin-sub-type; rheumatoid factor; or antibody to the antigen, used in a competitive or blocking fashion), or any molecule containing an epitope contained in the polypeptide.

The detectable signal may be optical or radioactive or physico-chemical and may be provided directly by labelling the molecule or particle with, for example, a dye, radiolabel, electroactive species, magnetically resonant species or fluorophore, or indirectly by labelling the molecule or particle with an enzyme itself capable of giving rise to a measurable change of any sort. Alternatively the detectable signal may be obtained using, for example, agglutination, or through a diffraction or birefringent effect if the surface is in the form of particles.

Assays in which a PT-NANBH viral polypeptide itself is used to label an already captured antibody require some form of labelling of the antigen which will allow it to be detected. The labelling may be direct by chemically or passively attaching for example a radio label, magnetic resonant species, particle or enzyme label to the polypeptide; or indirect by attaching any form of label to a molecule which will itself react with the polypeptide. The chemistry of bonding a label to the PT-NANBH viral polypeptide can be directly through a moiety already present in the polypeptide, such as an amino group, or through an intermediate moiety, such as a maleimide group. Capture of the antibody may be on any of the surfaces already mentioned by any reagent including passive or activated adsorption which will result in specific antibody or immune complexes being bound. In particular, capture of the antibody could be by anti-species or anti-immunoglobulin-sub-type, by rheumatoid factor, proteins A, G and

the like, or by any molecule containing an epitope contained in the polypeptide.

The labelled PT-NANBH polypeptide may be used in a competitive binding fashion in which its binding to any specific molecule on any of the surfaces exemplified above is blocked by antigen in the sample. Alternatively, it may be used in a non-competitive fashion in which antigen in the sample is bound specifically or non-specifically to any of the surfaces above and is also bound to a specific bi- or poly-valent molecule (e.g. an antibody) with the remaining valencies being used to capture the labelled polypeptide.

Often in homogeneous assays the PT-NANBH viral polypeptide and an antibody are separately labelled so that, when the antibody reacts with the viral polypeptide in free solution, the two labels interact to allow, for example, non-radiative transfer of energy captured by one label to the other label with appropriate detection of the excited second label or quenched first label (e.g. by fluorimetry, magnetic resonance or enzyme measurement). Addition of either viral polypeptide or antibody in a sample results in restriction of the interaction of the labelled pair and thus in a different level of signal in the detector.

A suitable assay format for detecting PT-NANBH antibody is the direct sandwich enzyme immunoassay (EIA) format. A PT-NANBH viral polypeptide is coated onto microtitre wells. A test sample and a PT-NANBH viral polypeptide to which an enzyme is coupled are added simultaneously. Any PT-NANBH antibody present in the test sample binds both to the viral polypeptide coating the well and to the enzyme-coupled viral polypeptide. Typically, the same viral polypeptide is used on both sides of the sandwich. After washing, bound enzyme is detected using a specific substrate involving a colour change. A test kit for use in such an EIA comprises:

- (1) a PT-NANBH viral polypeptide labelled with an enzyme;

- (2) a substrate for the enzyme;
- (3) means providing a surface on which a PT-NANBH viral polypeptide is immobilised; and
- (4) optionally, washing solutions and/or buffers.

The viral polypeptides of the present invention may be incorporated into a vaccine formulation for inducing immunity to PT-NANBH in man. For this purpose the viral polypeptide may be presented in association with a pharmaceutically acceptable carrier.

For use in a vaccine formulation, the viral polypeptide may optionally be presented as part of an hepatitis B core fusion particle, as described in Clarke *et al* (*Nature*, 1987, 330, 381-384), or a polylysine based polymer, as described in Tam (*PNAS*, 1988, 85, 5409-5413). Alternatively, the viral polypeptide may optionally be attached to a particulate structure, such as liposomes or ISCOMS.

Pharmaceutically acceptable carriers include liquid media suitable for use as vehicles to introduce the viral polypeptide into a patient. An example of such liquid media is saline solution. The viral polypeptide itself may be dissolved or suspended as a solid in the carrier.

The vaccine formulation may also contain an adjuvant for stimulating the immune response and thereby enhancing the effect of the vaccine. Examples of adjuvants include aluminium hydroxide and aluminium phosphate.

The vaccine formulation may contain a final concentration of viral polypeptide in the range from 0.01 to 5 mg/ml, preferably from 0.03 to 2 mg/ml. The vaccine formulation may be incorporated into a sterile container, which is then sealed and stored at a low temperature, for example 4°C, or may be freeze-dried.

In order to induce immunity in man to PT-NANBH, one or more doses of the vaccine formulation may be administered. Each dose may be 0.1 to 2 ml, preferably 0.2 to 1 ml. A method for inducing immunity to PT-NANBH in man, comprises the administration of an effective amount of a vaccine formulation, as hereinbefore defined.

The present invention also provides the use of a PT-NANBH viral polypeptide in the preparation of a vaccine for use in the induction of immunity to PT-NANBH in man.

Vaccines of the present invention may be administered by any convenient method for the administration of vaccines including oral and parenteral (e.g. intravenous, subcutaneous or intramuscular) injection. The treatment may consist of a single dose of vaccine or a plurality of doses over a period of time.

The following transformed strains of E.coli were deposited with the National Collection of Type Cultures (NCTC), Central Public Health Laboratory, 61, Colindale Avenue, London, NW9 5HT on the indicated dates:

- i) E.coli TGl transformed by pDX113 (WD001); Deposit No. NCTC 12369; 7th December 1989
- ii) E.coli TGl transformed by pDX128 (WD002); Deposit No. NCTC 12382; 23rd February 1990.
- iii) E.coli TGl transformed by p136/155 (WD003); Deposit No. NCTC ; 28th November 1990.
- iv) E.coli TGl transformed by p156/92 (WD004); Deposit No. NCTC ; 28th November 1990.
- v) E.coli TGl transformed by p129/164 (WD005); Deposit No. NCTC ; 28th November 1990.

vi) E.coli TG1 transformed by pDX136 (WD006); Deposit No. NCTC ;  
28th November 1990.

In the Figures, Figure 1 shows a representation of the production of pDX122 described in Example 7, Figure 2 shows a representation of the production of two alternative fused sequences described in Example 17, and Figure 3 shows restriction maps of SEQ ID NO : 21 and 22.

In the Sequence Listing, there are listed SEQ ID NO : 1 to 25 to which references are made in the description and claims.

The following Examples serve to illustrate the invention.

EXAMPLE 1. Synthesis of cDNA

Pooled plasma (160 mls) from two individuals (referred to as A and L) known to have transmitted NANBH via transfusions was diluted (1:2.5) with phosphate buffered saline (PBS) and then centrifuged at 190,000g (e.g. 30,000rpm in an MSE 8x50 rotor) for 5hrs at 4°C. The supernatant was retained as a source of specific antibodies for subsequent screening of the cDNA libraries. The pellet was resuspended in 2mls of 20mM tris-hydrochloride, 2mM EDTA 3% SDS, 0.2M NaCl (2xPK) extracted 3 times with an equal volume of phenol, 3 times with chloroform, once with ether, and then precipitated with 2.5 volumes of ethanol at -20°C. The precipitate was resuspended in 10µl of 10mM tris-hydrochloride, 1mM EDTA at pH 8.0 (TE).

The nucleic acid was used as a template in a cDNA synthesis kit (Amersham International plc, Amersham, U.K.) with both oligo-dT and random hexanucleotide priming. The reaction conditions were as recommended by the kit supplier. Specifically, 1ul of the nucleic acid was used for a first strand synthesis reaction which was labelled with [ $\alpha$ -<sup>32</sup>P]dCTP (Amersham; specific activity 3000Ci/mmol) in a final volume of 20ul and incubated at 42°C for 1 hour. The entire first strand reaction was then used for second strand synthesis reaction,

containing E. coli RNaseH (0.8 U) and DNA polymerase I (23 U) in a final volume of 100ul, incubated at 12°C for 60 minutes then 22°C for 60 minutes. The entire reaction was then incubated at 70°C for 10 minutes, placed on ice, 1 U of T4 DNA polymerase was added and then incubated at 37°C for 10 minutes. The reaction was stopped by addition of 5ul of 0.2M EDTA pH8.

Unincorporated nucleotides were removed by passing the reaction over a NICK column (Pharmacia Ltd, Milton Keynes, U.K.) The cDNA was then extracted twice with phenol, three times with chloroform, once with ether and then 20 µg dextran was added before precipitation with 2.5 volumes of 100% ethanol.

#### EXAMPLE 2. Production of Expression Libraries

The dried cDNA pellet was resuspended in 5ul of sterile TE and then incubated with 500ng of EcoRI linkers (Pharmacia; GGAATTC phosphorylated) and 0.5 U of T4 DNA ligase (New England BioLabs, Beverley, MA, USA) in final volume of 10µl containing 20mM Tris-HCl pH7.5, 10mM MgCl<sub>2</sub>, 10mM DTT, 1mM ATP for 3 hours at 15°C. The ligase was inactivated by heating to 65°C for 10 minutes and the cDNA was digested with 180U of EcoRI (BCL, Lewes, U.K.) in a final volume of 100µl at 37°C for 1 hour. EDTA was added to a final concentration of 10mM and the entire reaction loaded onto an Aca34 (LKB) column. Fractions (50µl) were collected and counted. The peak of cDNA in the excluded volume (980 cpm) was pooled, extracted twice with phenol, three times with chloroform, once with ether and then ethanol precipitated.

The ds cDNA was resuspended in 5µl TE and ligated onto lambda gt11 EcoRI arms (Gibco, Paisley, Scotland) in a 10µl reaction containing 0.5U T4 DNA ligase, 66 mM tris-hydrochloride, 10mM MgCl<sub>2</sub>, 15mM DTT pH 7.6 at 15°C overnight. After inactivating the ligase by heating to 65°C for 10 minutes, 5ul of the reaction were added to an Amersham packaging reaction and incubated at 22°C for 2 hours. The packaged



material was titrated on E. coli strain Y1090 (Huynh et al 1985) and contained a total of  $2.6 \times 10^4$  recombinants.

Plating cells (Y1090) were prepared by inoculating 10 mls L-broth with a single colony from an agar plate and shaking overnight at 37°C. The next day 0.5mls of the overnight culture were diluted with 10mls of fresh L-broth and 0.1ml 1M  $MgSO_4$  and 0.1ml 20%(w/v) maltose were added. The culture was shaken for 2 hours at 37°C, the bacteria harvested by centrifugation at 5,000g for 10 minutes and resuspended in 5 mls 10mM  $MgSO_4$  to produce the plating cell stock. A portion (1ul) of the packed material was mixed with 0.2ml of plating cells, incubated at 37°C for 20 minutes before 3 mls of top agar were added and the entire mixture poured onto a 90mm L-agar plate. After overnight incubation at 37°C plaques were counted and the total number of recombinant phage determined. The remaining packaged material (500ul) was stored at 4°C.

Additional libraries were prepared in a substantially similar manner.

### EXAMPLE 3. Screening of Expression Libraries

The initial library described in Example 2 was plated out onto E. coli strain Y1090 at a density of about  $5 \times 10^3$  pfu per 140mm plate and grown at 37°C for 2 hours until the plaques were visible. Sterile nitrocellulose filters which had been impregnated with IPTG (isopropylthiogalactoside) were left in contact with the plate for 3 hours and then removed. The filters were first blocked by incubation with blocking solution [3%(w/v)BSA/TBS-Tween(10mM Tris-HCl pH8, 150mM NaCl, 0.05%(v/v) Tween 20) containing 0.05% bronidox] (20mls/filter) and then transferred to binding buffer [1%(w/v)BSA/TBS/Tween containing 0.05% bronidox] containing purified (by ion-exchange chromatography) antibodies from pooled A & L plasma (20µg/ml). After incubation at room temperature for 2 hours the filters were washed three times with TBS-Tween and then incubated in binding buffer

containing biotinylated sheep anti-human (1:250). After 1 hour at room temperature the filters were washed 3 times with TBS/Tween and then incubated in binding buffer containing streptavidin/peroxidase complex (1:100). The signal developed with DAB. Positive signals appeared as (coloured) plaques.

Out of a total of  $2.6 \times 10^4$  plaques screened, 8 positives were obtained on the first round screen. Using the filters as a template, the regions of the original plates corresponding to these positive signals were picked off using a sterile pasteur pipette. The agar plugs were suspended in 0.1 ml of SM buffer and the phage allowed to diffuse out. The titre of phage from each plug was determined on E. coli strain Y1090. The phage stock from each plug was then re-screened as before on individual 90mm plates at a density of about  $1 \times 10^3$  pfu per plate. Of 8 first round positives, one was clearly positive on the second round, i.e. >1% of plaques positive, this was called JG2. This corresponds to a positive rate of  $40/10^6$  in the library.

This and other positive phage identified in an similar way from other cDNA libraries described in Example 2 were then purified by repeated rounds of plaque screening at lower density (1-200 pfu/90mm plate) until 100% of the plaques were positive with the A&L antibody screen. Three such recombinant phage were JG1, JG2 and JG3.

#### EXAMPLE 4. Secondary Screening of JG1, JG2 and JG3 with Serum Panels

Each of the recombinant phage, JG1, JG2 and JG3, were plaque purified and stored as titred stocks in SM buffer at 4°C. These phage were mixed (1:1) with a stock of phage identified as negative in Example 3 and mixture used to infect E. coli strain Y1090 at 1000 pfu per plate. Plaque lifts were taken and processed as described in Example 3 except that the filters were cut into quadrants and each quadrant was incubated with a different antibody; these were A&L antibodies (20µg/ml); A plasma (1:500); L plasma (1:500) and H IgG (20µg/ml). H

is a patient expected to be positive for PT-NANBH antibodies because he was a haemophiliac who had received non-heat-treated Factor VIII. At the end of the reaction each filter was scored blind as positive (when there were clearly two classes of signal) or negative (when all plaques gave the same signal). This could be a subjective judgement and so the scores were compared and only those filters where there was a majority agreement were taken as positive. The results are presented in Table 1.

TABLE 1

	A&L	A	L	H
JG1	+	+	-	-
JG2	+	+	+	+
JG3	+	+	+	+

JG1 appeared only to react with antibodies from patient A and not L or H; this is not what would be expected of a true PT-NANBH related recombinant polypeptide and so JG1 was dropped from the analysis. However both JG2 and JG3 gave clear positive reactions with three PT-NANBH sera A, L and H; these were analysed further.

The type of analysis described above was repeated for JG2 and JG3 except that the filters were cut into smaller portions and these were incubated with panels of positive and negative sera. The panels of positive sera comprised one panel of 10 haemophiliac sera and one panel of 9 intravenous drug addict (IVDA) sera. These represented the best source of positive sera even though the actual positive rate was unknown. The panel of negative sera was obtained from accredited donors who have been closely monitored over many years by the North London Blood Transfusion Centre, Deansbrook Road, Edgware, Middlesex, U.K. and have never shown any sign of infection with a variety of agents including PT - NANBH. The results are presented in Tables 2 & 3.

TABLE 2

	I.D.	JG2	JG3
IVDAs	V19146	<u>4/4</u>	0/5
	V27083	2/4	0/5
	V29779	0/4	0/5
	V12561	0/5	<u>4/5</u>
	V15444	<u>3/4</u>	<u>5/5</u>
	V18342	<u>4/4</u>	0/5
	V8403	<u>3/4</u>	0/5
	V20001	<u>4/4</u>	0/5
	V21213	<u>3/4</u>	0/5
Haemophiliacs	M1582	<u>4/4</u>	<u>4/5</u>
	M1581	<u>5/5</u>	<u>5/5</u>
	M1575	<u>3/5</u>	0/5
	M1579	<u>5/5</u>	<u>5/5</u>
	M1585	<u>3/5</u>	0/5
	M1576	1/5	1/5
	M1580	1/5	0/5
	M1578	1/5	0/5
	M1587	1/5	<u>3/5</u>
	M1577	2/5	1/5

Positives are underlined.

TABLE 3

	IVDA	Haemophiliac	Accredited Donor
JG2	6/9(66%)	5/10(50%)	0/10(0%)
JG3	2/9(22%)	4/10(40%)	0/10(0%)
JG2+JG3	1/9(11%)	3/10(30%)	0/10(0%)
JG2 or JG3	7/9(77%)	6/10(60%)	0/10(0%)

These data are consistent with the hypothesis that both recombinants are expressing polypeptides associated with an agent responsible for PT-NANBH and that these polypeptides are not identical but may share some antigenic sites.

EXAMPLE 5. Restriction Mapping and DNA Sequencing of JG2 and JG3

A portion (10 $\mu$ l) of the phage stocks for both JG2 and JG3 was boiled to denature the phage and expose the DNA. This DNA was then used as a template in a PCR amplification using Taq polymerase; each reaction contained the following in a final volume of 50 $\mu$ l:- 10mM Tris-HCl, 50mM KCl, 1.5mM MgCl<sub>2</sub>, 0.01% gelatin, pH 8.3 at 25°C plus oligonucleotide primers d19 and d20 (SEQ ID NO : 1 and 2 respectively; 200ng each); these primers are located in the lambda sequences flanking the Eco RI cloning site and therefore prime the amplification of anything cloned into this site.

A portion of the reaction was analysed on a 1.0% agarose gel and compared to markers. Amplification of JG2 produced a fragment of approximately 2Kb; JG3 one of approximately 1Kb. The remaining reaction mix was extracted with phenol/chloroform in the presence of 10mM EDTA and 1% SDS and the DNA recovered by ethanol precipitation. The amplified material was then digested with 20U of EcoRI for 60 minutes at 37°C and separated on a 1.0% LGT agarose gel in TAE. The fragments were reduced in size as expected and were eluted and purified using Elutips (S&S). The JG2 and JG3 inserts were ligated with EcoRI digested pUC13 and transformed into *E. coli* strain TG1. Recombinants were identified as white colonies on X-gal/L-Amp plates (L-Agar plates supplemented with 100  $\mu$ g/ml ampicillin, 0.5 mg/ml X-gal) and were checked by small-scale plasmid preparations and EcoRI restriction enzyme digestion to determine the size of the insert DNA. The recombinant plasmid containing the JG2 insert was called DM415 and that containing the JG3 insert was called DM416.

The sequence of the JG2 insert was determined by direct double-stranded sequencing of the plasmid DNA and by subcloning into M13 sequencing vectors such as mp18 and mp19 followed by single-stranded sequencing. The sequence of the JG3 insert was similarly determined. The resulting DNA and deduced amino acid sequences are set forth in SEQ ID NO : 3 and 4.

EXAMPLE 6. Expression of PT-NANBH Polypeptide in E.coli

The plasmid pDM416 (5ug) was digested with EcoRI (20U) in a final volume of 20ul and the 1Kb insert recovered by elution from a 1% LGT agarose gel. This material was then "polished" using Klenow fragment and a dNTP mix to fill in the EcoRI overhanging ends. The DNA was recovered by ethanol precipitation following extraction with phenol/chloroform. The blunt-ended fragment was ligated into SmaI cleaved/phosphatased pDEV107 (a vector which permits cloning at the 3' end of *lac Z*) and then transformed into *E. coli* TGI cells. There was a 30-fold increase in colonies over a vector-alone control. Transformants containing the required recombinant plasmid were identified by hybridisation with a radioactive probe produced by PCR amplification of the JG3 recombinant. Twelve colonies were analysed by restriction enzyme digestion (SalI) of plasmid mini-preparations to determine the orientation of the insert. A quarter of these recombinants were in the correct orientation to express the PT-NANBH sequence as a fusion with  $\beta$ -galactosidase. One of these (pDX113) was taken for further analysis.

A colony of pDX113 was used to inoculate 50 mls L-broth, grown at 37°C with shaking to mid-log phase and expression induced by addition of 20mM IPTG. After 3 hours the cells were harvested by centrifugation at 5,000g for 20 minutes, resuspended in 50 mls PBS and repelleted. The pelleted cells were resuspended in 5 mls of buffer (25mM Tris-HCl, 1mM EDTA, 1mg/ml lysozyme, 0.2%(v/v) Nonidet-P40, pH8.0) per gram of pellet and incubated at 0°C for 2 hours. The released bacterial DNA

was digested by addition of DNase I and  $MgSO_4$  to final concentrations of 40ug/ml and 2mM respectively to reduce viscosity.

This crude lysate was analysed by PAGE and the pattern of proteins stained with Coomassie blue. A protein of approximately 150kD was induced in bacteria containing pDX113 and this protein was estimated to account for 10-15% of the total protein. Similar gels were transferred to PVDF membrane (GRI, Dunmow, Essex, U.K.) and the membranes incubated with PT-NANBH-positive and negative sera; the 150kD protein reacted with the A and L sera but not normal human serum. Control tracks containing lysate from *E. coli* expressing  $\beta$ -galactosidase did not react with A, L or normal human sera.

Urea was added to the crude lysate to a final concentration of 6M and insoluble material removed by centrifugation. The 6M urea extract was used to coat microtitre wells directly for 1 hour at 37°C. The wells were washed three times with double-distilled water and then blocked by addition of 0.25ml of 0.2% BSA per well containing 0.02%  $NaN_3$  for 20 minutes at 37°C. The plate was then aspirated. Control plates coated with a crude lysate of a  $\beta$ -galactosidase-producing *E. coli* strain (pXY461) were produced in the same way. These plates were used in ELISA assays as described in Example 10.

#### EXAMPLE 7. Expression of PT-NANBH Polypeptide in Insect Cells

The PT-NANBH insert from JG3, isolated as described in Example 5, was cloned in-frame with the first 34 nucleotides of polyhedrin in the vector pAc360 (Luckow and Summers, *Biotechnology*, 1988, 6, 47-55), utilising our knowledge of the reading frame of the *lacZ* gene in the gtl1 vector. Oligonucleotides were synthesised which were able to hybridise to gtl1 sequences flanking the EcoRI cloning site and which would enable the amplification of the insert by PCR. These oligonucleotides included BamHI restriction sites suitably placed to allow direct cloning into the BamHI site of pAc360, placing the

inserted gene in-frame with the amino terminal sequences of polyhedrin.

A small amount of the gtl1 recombinant JG3 was boiled to expose the DNA and then used in a PCR amplification containing the oligonucleotide primers d75 and d76 (SEQ ID NO : 6 and 7; 200mg) and 0.5U of Taq polymerase.

After amplification, the reaction was extracted with an equal volume of phenol/chloroform, ethanol precipitated and digested with 10U BamHI in a final volume of 30ul. The amplified fragment was resolved on a 1% agarose gel, eluted and ligated into BamHI-digested pAc360 to produce the transfer construct pDX119. The recombinant plasmid (2ug) and wild-type AcNPV DNA (1ug) were co-transfected into insect cells by calcium phosphate precipitation. Inclusion negative recombinant virus was selected by visual screening. After three rounds of plaque purification, the recombinant virus (BHC-5) was expanded and expression of recombinant protein in insect cells was assessed by SDS-PAGE, Western blot and ELISA. An abundantly expressed protein of approximately 70kD was produced in infected cells. This protein is reactive with PT-NANBH sera by Western blot and ELISA.

A further baculovirus recombinant (BHC-7) was constructed to include JG2 sequences additional to the JG3 sequences present in BHC-5, as depicted in Figure 1. The PT-NANBH sequences present in JG2 were amplified and cloned into the pAc360 vector as described above to produce pDX118 and the appropriate Bam HI/Sal I fragments of pDX119 and pDX118 were linked together in that order in pAc360 to produce the transfer construct pDX122.

Recombinant plasmids were identified by hybridisation and orientation of inserted DNA determined by restriction enzyme analysis. Recombinant virus was produced as described above and the expressed protein analysed by SDS-PAGE, Western blot and ELISA. A very abundant



(40% total cell protein) 95kDa polypeptide which reacted with PT-NANBH sera was found in infected cells.

EXAMPLE 8. Purification of DX113 Polypeptide

E. coli strain TG1 containing the plasmid pDX113 (designated strain WDL001) was grown and induced in a 1.5 litre fermenter (model SET002, SGI, Newhaven, East Sussex, U.K.) at 37°C for 5 hours. The cells were harvested by centrifugation at 5,000g for 20 minutes and treated as follows.

a) Extraction.

The wet cells are resuspended (1:20, w/v) in Buffer A (50mM Tris-HCl, 50mM NaCl, 1mM EDTA, 5mM DTT, 10%(v/v) glycerol, pH8.0). Lysozyme was added at 5mg solid per ml of suspension and the mixture left at 4°C. After 15 minutes, the mixture was sonicated (6um peak-to-peak amplitude) on ice for a total of 3 minutes (6x 30 sec bursts). DNase I was added at 4ug per ml suspension and the mixture left for a further 30 minutes. The suspension was centrifuged for 20 minutes at 18,000g(max) and the supernatant discarded.

The pellet was resuspended in buffer B (25mM Hepes, 4M urea, 5mM DTT, pH 8.0) at a ratio of 1:6 (w/v) to obtain a fine suspension. This was centrifuged at 18,000g(max) for 20 minutes and the supernatant discarded. The pellet was resuspended in buffer C (25mM Hepes, 8M urea, 2mM DTT, pH 8.0) at a ratio of 1:6 (w/v); before suspension the following are added:- leupeptin (1ug/ml), pepstatin (1ug/ml) and E64 (1ug/ml). The suspension was centrifuged at 18,000g(max) for 30 minutes and the supernatant decanted and kept. The pellet was resuspended in 25mM Hepes, 1% SDS pH 8.0.

b) Chromatography.

The supernatant from the 8M urea fraction was diluted 1:5 (v/v) in 25mM Hepes, 8M urea, 2mM DTT, pH 8.0 and fractionated on a 7ml Q-Sepharose column. Proteins were eluted via a salt gradient of 0-1M NaCl. The chromatography and data manipulation were controlled by an FPLC (Pharmacia). DX113 elutes at approximately 500mM NaCl and is virtually homogeneous by SDS Page and Western blot analysis.

EXAMPLE 9. Purification of BHC-5 Polypeptide

Sf9 cells ( $2 \times 10^9$ ) were infected with a stock of the BHC-5 recombinant virus (moi 5). After incubation at 28°C for 2 days the cells were harvested by centrifugation and then processed as follows.

a) Extraction.

The wet cell mass (1.2g) was resuspended in 6mls of buffer A (25mM Hepes, 5mM DTT, leupeptin 1µg/ml, pepstatin 1µg/ml, E64 1µg/ml pH 8.0). The resuspended cells were placed on ice and sonicated for 3 x 15 seconds bursts (6µm peak-to-peak amplitude) interspersed with 30 second rest periods. The sonicated suspension was centrifuged at 18,000g(max) for 20 minutes and the supernatant discarded. The pellet was resuspended in buffer A plus 4M urea (6mls) and centrifuged at 18,000g (max) for 20 minutes. The supernatant was discarded and the pellet re-extracted with buffer A plus 8M urea (6ml). After centrifugation at 18,000g (max) for 30 minutes the supernatant was retained and diluted 1:6 in buffer A plus 8M urea. This extract was chromatographed on a mono-Q column equilibrated in the same buffer. The column was eluted via a salt gradient (0-1.0M NaCl) over 12 column volumes. BHC-5 eluted at approximately 0.45 - 0.55M NaCl and was greater than 90% pure as judged by SDS-PAGE. The yield, was approximately 70%.

EXAMPLE 10.

Performance of DX113 and BHC-5 and 7 Polypeptides in an ELISA

Microelisa plates (96 well, Nunc) were directly coated in 50mm bicarbonate buffer (50mM sodium bicarbonate and 50mM sodium carbonate, titrated to pH 9.5) with either a crude 6M urea lysate of BHC-5 or with purified pDX113. Plates were blocked with 0.2% BSA and then incubated for 30 minutes at 37°C with sera diluted 1:20 (baculo) or 1:100 (*E. coli*). After washing in Tween-saline (0.85% saline, 0.05% Tween 20, 0.01% Bronidox) plates were incubated with peroxidase-conjugated goat anti-human immunoglobulin (1:2000) for 30 minutes at 37°C. Plates were then washed in Tween-saline and colour developed by adding the chromogenic substrate TMB (tetramethyl benzidine-HCl) (100µl/well) and incubating for 20 minutes at room temperature. The reaction was stopped with 50µl 2M sulphuric acid and the OD450 determined (Table 4;)

TABLE 4

Indirect anti-human Ig format ELISA for the detection of NANB antibody

	<u>Baculo</u>	<u>E.coli</u>
	BHC-5 (Solid phase)	DX113 (Solid phase)
	>2	1.670
	1.855	1.531
	1.081	1.015
Sera from high risk	1.842	1.558
patients positive	0.526	0.638
in the assay	>2	1.516
	1.823	1.602
	1.779	1.318
	1.122	0.616
	1.686	1.441

	0.259	0.205
	0.158	0.120
	0.298	0.209
Sera from high risk	0.194	0.111
patients negative	0.282	0.181
in the assay	0.263	0.165
	0.184	0.163
	0.121	0.099
	0.243	0.104
Accredited donor	0.224	0.119

Sera from patients at high risk of PT-NANB infection (IVDA's, haemophiliacs) were assayed as described; all data are expressed as OD450 readings with the accredited donor as a negative control. Of this particular group of sera 10/19 are positive on both solid phases.

Additionally purified DX113 was conjugated to alkaline phosphatase using SATA/maleimide reduction and an immunometric assay was established. Known NANB positive and negative sera were diluted as indicated in accredited donor serum and added to a BHC-7 coated solid phase. Either simultaneously or after incubation (30 minutes at 37°C) the DX113 conjugate was added (50µl, 1:2000). After incubation at 37°C for 30 minutes, plates were washed with 50mM bicarbonate buffer and colour developed using the IQ Bio amplification system and the OD492 determined (Table 5)

TABLE 5

Immunometric (labelled polypeptide) ELISA for the detection of NANB antibody

<u>Positive in</u> <u>Assay</u>	<u>Negative in</u> <u>Assay</u>	<u>Accredited donor</u>
>2	0.217	0.234
0.821	0.252	
>2	0.214	
0.542	0.257	
0.876	0.308	
1.583	0.278	
>2	0.296	
>2	0.273	
1.830	0.262	
>2	0.251	

Thus with either assay format - antiglobulin or immunometric - all the high risk samples gave concordant results.

EXAMPLE 11 - Vaccine Formulation

A vaccine formulation may be prepared by conventional techniques using the following constituents in the indicated amounts:

PT-NANBH Viral polypeptide	> 0.36 mg
Thiomersal	0.04-0.2 mg
Sodium Chloride	< 8.5 mg
Water	to 1ml

EXAMPLE 12 -

Production of Monoclonal Antibodies to PT-NANBH Polypeptides

The DNA insert from DM415 was sub-cloned into the baculovirus transfer vector p36C and recombinant virus produced by a method essentially similar to that described in Example 7. The recombinant virus was called BHC-1 and expressed very low levels of PT-NANBH-specific protein. Sf-9 cells ( $5 \times 10^7$  cells/ml) infected with BHC-1 were lysed in PBS containing 1% (v/v) NP40 and spun at 13000g for 2 minutes. The supernatant was passed over Extractigel-D (Pierce Chemicals) to remove detergent and then mixed as a 1:1 emulsion with Freund's complete adjuvant. Mice were injected subcutaneously with 0.1ml of emulsion (equivalent to  $5 \times 10^6$  cells). At 14 and 28 days post-injection, the mice were boosted by intraperitoneal injection of 0.1ml (equivalent to  $5 \times 10^6$  cells) of a detergent-free extract of BHC-5-infected Sf-9 cells: BHC-5 contains the DNA insert of DM416. Test tail bleeds were taken and assayed for anti-PT-NANBH activity in an ELISA (Example 10). Two mice with a PT-NANBH-specific response were further boosted by i.v. injection with a detergent-free extract of BHC-7-infected Sf-9 cells; BHC-7 contains a DNA insert produced by ligating together the overlapping regions of DM415 and DM416 (Example 7). The spleens were removed three days later.

Spleen cells were fused with NS0 myeloma cells in the presence of PEG1500 by standard techniques. The resulting hybridoma cells were selected by growth in HAT (hypoxanthine, aminopterin, thymidine) medium. At 10-14 days post-fusion, supernatants were screened for anti-PT-NANBH activity by ELISA. Wells which showed reactivity with both DX113 and BHC-7 antigens (Example 10) were identified and individual colonies were transferred to separate wells, grown and re-tested. Wells which showed specific reactivity at this stage were further cloned at limiting dilution to ensure monoclonality.

#### EXAMPLE 13. Detection of PT-NANBH Viral Nucleic Acid in Seropositive Patients

Sera: Donation samples from 1400 donors, enrolled into a prospective study of post-transfusion hepatitis, were frozen at  $-20^{\circ}\text{C}$ .

Pre-transfusion and serial post-transfusion samples from the 260 recipients were similarly stored. The post-transfusion samples were collected fortnightly until 3 months, monthly until 6 months and 6 monthly thereafter, until 18 months. Frozen donor and recipient sera from three incidents of PT-NANBH that occurred in 1981 were also available for study. The diagnosis of PT-NANBH was based on a rise in serum alanine amino transferase (ALT) to exceed 2.5 times the upper limit of normal in at least two separate post-transfusion samples. Other hepatotropic viruses were excluded by serological testing and non-viral causes of hepatocellular injury were excluded by conventional clinical and laboratory studies.

Immunoassay: Serum samples were tested retrospectively for the presence of antibodies to HCV (C100 antigen) with the Ortho Diagnostics ELISA kit used in accordance with the manufacturer's instructions. Repeatedly reactive sera were titrated to end points in a human serum negative for anti-C100.

Detection of PT-NANBH Viral Sequences: Serum or plasma RNA was extracted, reverse transcribed, and amplified as described below. The reverse transcription/PCR oligonucleotide primers were derived from the nucleotide sequence of the JG2 clone isolated in EXAMPLE 3, and synthesised on an Applied Biosystems 381A synthesiser. The sequences of the four oligonucleotide primers were as follows:

<u>Designation</u>	<u>SEO ID NO :</u>	<u>Product Size</u>
d94 sense	8	729bp
d95 antisense	9	
N1 sense	10	402bp
N2 antisense	11	

(i) RNA Extraction

5-50 $\mu$ l of serum (or plasma) was made up to 200 $\mu$ l by adding sterile distilled water. The 200 $\mu$ l sample was added to an equal volume of 2 x PK buffer (2 x PK = 0.2M TrisCl, pH7.5, 25mM EDTA, 0.3M NaCl, 2% w/v SDS, proteinase K 200 $\mu$ g/ml), mixed and incubated at 37°C for 40 minutes. Proteins were removed by extracting twice with phenol/chloroform and once with chloroform alone. 20 $\mu$ g glycogen were added to the aqueous phase and the RNA then precipitated by addition of 3 volumes of ice-cold absolute ethanol. After storage at -70°C for 1 hour the RNA was pelleted in an Eppendorf centrifuge (15 minutes, 14000 rpm, 4°C). The pellet was washed once in 95% ethanol, vacuum desiccated and dissolved in 10 $\mu$ l of sterile distilled water. RNA solutions were stored at -70°C.

(ii) cDNA Synthesis

A 10 $\mu$ l mixture was prepared containing 2 $\mu$ l of the RNA solution, 50ng of the synthetic oligonucleotide d95, 10mM Hepes-HCl pH6.9 and 0.2mM EDTA pH8.0. This 10 $\mu$ l mix was overlayed with 2 drops of mineral oil, heated for 2 minutes in a water bath at 90°C and cooled rapidly on ice. cDNA synthesis was performed after adjusting the reaction to contain 50mM Tris-HCl pH7.5, 75mM KCl, 3mM MgCl<sub>2</sub>, 10mM DTT, 0.5mM each of dATP, dCTP, dGTP and dTTP, 20 units of RNase inhibitor (Pharmacia) and 15 units of cloned MLV reverse transcriptase (Pharmacia) in a final volume of 20 $\mu$ l. The 20 $\mu$ l mix was incubated at 37°C for 90 minutes. Following synthesis the cDNA was stored at -20°C.

(iii) "Nested" PCR

Throughout this study false positive PCR results were avoided by strict application of the contamination avoidance measures of Kwok and Higuchi (Nature, 1989, 339, 237-238).



a) Round 1

The polymerase chain reaction was performed in a 50 $\mu$ l mix containing 10mM Tris-HCl pH8.3, 50mM KCl, 1.5mM MgCl<sub>2</sub>, 0.01% w/v gelatin, 1 Unit Recombinant Taq DNA polymerase (Perkin Elmer Cetus), 200 $\mu$ M each dNTP, 30ng of each 'outer' primer (d94 and d95; SEQ ID NO : 8 and 9 respectively) and 5 $\mu$ l of the cDNA solution. After an initial 5 minute denaturation at 94°C, 35 cycles of 95°C for 1.2 minutes, 56°C for 1 minute, 72°C for 1 minute were carried out, followed by a final 7 minute extension at 72°C (Techne PHC-1 Automated Thermal Cycler).

b) Round 2

The reaction mix was as described above for Round 1 but 125ng of each 'inner' primer, N1 and N2 (SEQ ID NO : 10 and 11 respectively), was used instead of the 'outer' primers d94 and d95. A 1 $\mu$ l aliquot of the Round 1 PCR products was transferred to the Round 2 50 $\mu$ l reaction mix. 25 cycles of 95°C for 1.2 minutes, 46°C for 1 minute, 72°C for 1 minute were performed followed by a 7 minute extension at 72°C.

c) Analysis

20 $\mu$ l of the Round 1 and Round 2 PCR products were analysed by electrophoresis on a 2% agarose gel. Bands were visualised by ethidium bromide staining and photographed at 302nm.

Predictive Value of Anti-HCV Serology and PCR in the Prospective Study: Six of the 1400 donors (0.43%) enrolled into the prospective study were found to have antibodies to C100 in their serum. Of these six antibody positive donors only one (donor D6) proved to be infectious as judged by the development of PT-NANBH and C100 seroconversion in a recipient (recipient R6) - see Table 6 below.

Viral sequences were detected by PCR in the serum of donor D6 but not in any of the other five seropositive donor sera. The recipient R6 who developed PT-NANBH had also received blood from seven other donors (D7 to D13). Sera from these donors were tested and found to be both antibody negative and PCR negative.

TABLE 6  
DONOR/RECIPIENT DATA SUMMARY : PROSPECTIVE STUDY

<u>DONORS</u>			<u>RECIPIENTS</u>		
Donor	anti-HCV	PCR	Recipient	PT-NANBH	Anti-HCV serocon- version
D1	+	-	R1	No	No
D2	+	-	R2	No	No
D3	+	-	R3	No	No
D4	+	-	R4	No	No
D5	+	-	R5	No	No
D6	+	+			
D7	-	-			
D8	-	-			
D9	-	-	R6	Yes*	Yes+
D10	-	-			
D11	-	-			
D12	-	-			
D13	-	-			

\* incubation period 1 month

+ Seroconversion occurred at 5 months post-transfusion

Example 14 -

Isolation and Expression of Additional PT-NANBH DNA Sequences

The lambda gt11 libraries prepared in Example 2 were also screened with sera from patients with a high risk for PT-NANBH but which did not react with the viral antigens, DX113, BHC-5 and BHC-7, the reasoning being that they might well contain antibodies which recognise different antigens. The sera, PJ-5 (The Newcastle Royal Infirmary, Newcastle), Birm-64 (Queen Elizabeth Medical Centre, Birmingham), PG and Le (University College and Middlesex School of Medicine, London) met this criterion and were used to screen the libraries following the same procedure as described in Examples 3 and 4. A number of recombinants were thus identified, none of which cross-hybridised with probes made from JG2 and JG3. One of the recombinants, BR11, identified by reaction with PJ-5, was selected for further analysis.

The clone, BR11, contained an insert of approximately 900bp which was amplified by PCR using the d75 and d76 primers (SEQ ID NO : 6 and 7) as described in Example 7. The amplified sequence was directly cloned into the baculovirus vector pAc360 to form pDX128 containing an open reading frame in phase with the first 11 amino acids of polyhedrin. Recombinant baculovirus stocks (designated BHC-9) were produced following the procedure described in Example 7. Insect cells were infected with purified recombinant virus and a polypeptide of approximately 22kD was obtained in radiolabelled cell extracts.

The amplified insert of BR11 was also cloned into pUC13 and M13 phage vector for sequencing; the DNA and amino acid sequence data are presented in SEQ ID NO : 5. The insert contains 834bp plus the EcoRI linkers added during cloning.

Example 15 - Performance of BHC-9 Polypeptide in an ELISA

An ELISA was established using microtitre wells coated with BHC-9-infect cell extract and an anti-human Ig conjugate detection system following the procedure as described in Example 10. A panel of high-risk sera were assayed in parallel against BHC-7 and BHC-9 and were also examined by PCR using the procedure described in Example 13. The results are shown in Table 7 in which positive samples are underlined.

TABLE 6

<u>Number</u>	<u>PCR</u>	<u>BHC-7</u>	<u>BHC-9</u>
1	+	<u>2.09</u>	<u>2.00</u>
2	+	<u>2.09</u>	<u>2.00</u>
3	+	<u>1.89</u>	<u>1.37</u>
4	+	<u>1.57</u>	0.27
5	+	<u>1.26</u>	<u>2.00</u>
6	+	<u>0.91</u>	<u>2.00</u>
7	-	<u>0.90</u>	<u>0.51</u>
8	+	<u>0.84</u>	<u>1.19</u>
9	-	<u>0.53</u>	<u>0.43</u>
10	-	<u>0.45</u>	<u>2.00</u>
11	+	0.37	<u>1.07</u>
12	-	0.32	<u>2.00</u>
13	-	0.23	0.30
14	-	0.15	<u>0.43</u>
15	+	0.16	<u>0.76</u>
16	-	0.09	<u>1.74</u>
17	-	0.27	<u>2.00</u>
18	-	0.15	<u>2.00</u>
19	-	0.12	<u>2.00</u>
20	-	0.08	0.05
cut-off		0.27	0.29

Of these 20 samples, 50% are clearly positive with BHC-7 whereas 85% are positive with BHC-9. Two samples (11 & 12) which are borderline positive with BHC-7 are clearly positive with BHC-9 and some of the samples at or below the cut off with BHC-7 are positive with BHC-9. In addition, two samples (11 & 15) which were borderline or negative with BHC-7 but positive with BHC-9 are PCR-positive. Overall there are only two samples (13 & 20) which are negative with both polypeptides and PCR.

Example 16 -

Isolation of PT-NANBH DNA sequences overlapping existing clones

The immunological screening of cDNA expression libraries described in Examples 3,4 and 14, can only identify those clones which contain an immunoreactive region of the virus. Another approach to the production of clones specific for PT-NANBH is to use PCR to amplify cDNA molecules which overlap the existing clones. Sets of primers can be prepared where one member of the pair lies within existing cloned sequences and the other lies outside; this approach can be extended to nested pairs of primers as well.

cDNA, prepared as described in Example 1, was amplified by PCR, with either single or nested pairs of primers, using the reaction conditions described in Example 13. The approach is illustrated by use of the following pairs of primers; d164 (SEQ ID NO : 12) and d137 (SEQ ID NO : 13); d136 (SEQ ID NO : 14) and d155 (SEQ ID NO : 15); d156 (SEQ ID NO : 16) and d92 (SEQ ID NO : 17). One member of each pair is designed to prime within existing cloned sequences (d137 and d136 prime within the 5' and 3' ends of BR11 respectively, d92 primes at the 5' end of JG3). The other primers are based upon sequences available for other PT-NANBH agents. Primer d164 corresponds to bases 10 to 31 of figure 2 in Okamoto *et al*, Japan. J. Exp. Med., 1990, 60 167-177. Primers d155 and d156 correspond to positions 462 to 489 and 3315 to 3337 respectively in figure 47 of European Patent Application 88310922.5. One or more nucleotide substitutions were made to

introduce an EcoRI recognition site near the 5' end of the primers, except for dl64 where a BglII recognition site was introduced; these changes facilitate the subsequent cloning of the amplified product.

The PCR products were digested with the appropriate restriction enzyme(s), resolved by agarose gel electrophoresis and bands of the expected size were excised and cloned into both plasmid and bacteriophage vectors as described in Example 5. The sequences of the amplified DNAs 164/137 (SEQ ID NO : 18), 136/155 (SEQ ID NO : 19) and 156/92 (SEQ ID NO : 20) are presented in the Sequence Listing. These new sequences extend the coverage of the PT-NANBH genome over that obtained by immunoscreening (SEQ ID NO : 3, 4 & 5). These sequences, together with others which lie within the regions already described, can be combined into a contiguous sequence at the 5' end (SEQ ID NO : 21) and at the 3'-end (SEQ ID NO : 22) of the PT-NANBH genome.

#### Example 17

##### Fusion of Different PT-NANBH Antigens into a Single Recombinant Polypeptide

The data presented in Table 7 indicate that whilst more serum samples are detected as antibody-positive using BHC-9 as a target antigen (17/20) rather than BHC-7 (10/20) there are some samples (e.g. #4) which are positive with only BHC-7. This picture is borne out by wider testing of samples. Accordingly, a fusion construct was derived using sequence from BHC-7 and BHC-9.

Sequences from BHC-7 and BHC-9 may be combined in a variety of ways; either sequence may be positioned at the amino terminus of the resulting fusion and the nature of the linking sequence may also be varied. Figure 2 illustrates two possible ways in which the sequences may be combined.

Appropriate restriction fragments carrying suitable restriction enzyme sites and linker sequences were generated either by PCR using specific

primers or by restriction enzyme digestion of existing plasmids. The transfer vector DX143 consists of a BamHI/PstI fragment from DX122 (Figure 1; the Pst site is at position 1504 JG2, SEQ ID NO:3) linked to the 5' end of the entire coding region of BR11 (SEQ ID NO:7) which has been amplified as a PstI/BamHI fragment using primers d24 (SEQ ID NO:23) and d126 (SEQ ID NO:24); the linkage region consists of six amino acids derived from the d126 primer and residual bacteriophage lambda sequences. The transfer vector DX136 differs from DX143 in that the BR11 fragment was generated using d24 (SEQ ID NO : 23) and d132 (SEQ ID NO : 25) and so the linkage region contains five lysines. These transfer vectors were used to co-transfect Sf9 insect cells in culture with AcNPV DNA and plaque purified stocks of recombinant baculoviruses were produced as described in Example 7. BHC-10 was produced as a result of transfection with DX143; BHC-11 as a result of transfection with DX136.

The recombinant polypeptides expressed by these two viruses were analysed by SDS-PAGE and western blotting. BHC-10 produced a polypeptide with an apparent molecular weight of 118kDa. BHC-11 produced a polypeptide with an apparent molecular weight of 96kDa. Both polypeptides reacted with sera known to react in ELISA only with BHC-7 (e.g. serum A) or only with BHC-9 (serum B64, Example 14). The two polypeptides only differ in the linker sequence and this may affect either their mobility on SDS-PAGE or how they are processed in the infected cells.

#### Example 18 -

##### Performance of PT-NANBH Fusion Antigens in an ELISA

An ELISA was established using microtitre wells coated with BHC-9-infected cell extracts and an anti-human Ig conjugate following the procedure described in Example 10. Table 8 presents the data from a comparison of the two fusions with the other PT-NANBH recombinant antigens BHC-7 and BHC-9 as well as the HCV recombinant protein C-100-3 (Ortho Diagnostic Systems, Raritan, New Jersey). The sera are

grouped by pattern of reaction with BHC-7, BHC-9 and C-100-3. Group I sera react strongly with all three antigens; Group II react strongly with only BHC-7; Group III react strongly with only BHC-9 and Group IV react strongly with only two out of the three antigens.

TABLE 8

SERUM	BHC-7	BHC-9	C-100-3	BHC-10	BHC-11
<u>Group I</u>					
AH	>2.0	>2.0	>2.0	>2.0	>2.0
AC	>2.0	>2.0	>2.0	>2.0	>2.0
57	>2.0	>2.0	>2.0	>2.0	>2.0
77	>2.0	>2.0	>2.0	>2.0	>2.0
84	1.4	>2.0	>2.0	>2.0	>2.0
<u>Group II</u>					
805-6	>2.0	0.261	0.1	1.78	+*
805-17	>2.0	0.181	0.12	1.37	+*
805-149	>2.0	0.651	0.084	1.57	++*
<u>Group III</u>					
JS	0.32	>2.0	0.17	>2.0	>2.0
805-57	0.069	1.403	0.25	1.9	+*
805-82	0.116	1.272	0.4	1.85	++*
805-94	0.353	1.675	0.2	>2.0	+*
PJ1	0.27	>2.0	0.2	>2.0	1.85
<u>Group IV</u>					
A	>2.0	0.14	>2.0	>2.0	>2.0
KT	1.57	0.27	>2.0	>2.0	>2.0
Le	0.152	>2.0	>2.0	>2.0	>2.0
PJ5	0.123	>2.0	>2.0	>2.0	>2.0
303-923	>2.0	0.9	0.37	1.9	+*
303-939	>2.0	1.55	0.268	2.0	+*



\* These samples have only been tested by western blotting on BHC-11.

These data show that both BHC-10 and BHC-11 have a similar reactivity with these sera and, most importantly, that the both antigenic activities appear to have been retained by the fusions. All the sera in Groups II & III, which react with only BHC-7 or BHC-9 respectively, give a clear reaction with the fusions. Additionally there is an indication that having the two antigens together gives a more sensitive assay. For example the sample KT gives ODs of 1.57 and 0.27 with BHC-7 and BHC-9 respectively whereas with the fusions the OD is >2.0.

SEQ ID NO:1

SEQUENCE TYPE:Nucleotide

SEQUENCE LENGTH:21 BASES

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:bacteriophage lambda gt11

IMMEDIATE EXPERIMENTAL SOURCE:Oligonucleotide synthesiser; oligo d19

FEATURES:

from 1 to 21 bases homologous to upstream portion of lacZ gene  
flanking the EcoR1 site in bacteriophage lambda gt11

PROPERTIES:primes DNA synthesis from the phage vector into cDNA  
inserted at the EcoR1 site.

GGTGGCGACG ACTCCTGGAG C

21

SEQ ID NO:2  
SEQUENCE TYPE:Nucleotide  
SEQUENCE LENGTH:21 BASES

STRANDEDNESS:single  
TOPOLOGY:linear  
MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:bacteriophage lambda gt11  
IMMEDIATE EXPERIMENTAL SOURCE:Oligonucleotide synthesiser; oligo d20

FEATURES:

from 1 to 21 bases homologous to downstream portion of lacZ gene  
flanking the EcoR1 site in bacteriophage lambda gt11

PROPERTIES:primes DNA synthesis from the phage vector into cDNA  
inserted at the EcoR1 site.

TTGACACCAG ACCAACTGGT A

21

SEQ ID NO:3

SEQUENCE TYPE:Nucleotide with corresponding protein

SEQUENCE LENGTH:1770 BASE PAIRS

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:cDNA to genomic RNA

ORIGINAL SOURCE ORGANISM:human; serum infectious for  
post-transfusional non-A, non-B hepatitis

IMMEDIATE EXPERIMENTAL SOURCE:clone JG2 from cDNA library in lambda  
gt11

FEATURES:

from 1 to 1770 bp portion of the PT-NANBH polyprotein

PROPERTIES:probably encodes viral non-structural proteins

CAA AAT GAC TTC CCA GAC GCT GAC CTC ATC GAG GCC AAC CTC CTG TGG	48
Gln Asn Asp Phe Pro Asp Ala Asp Leu Ile Glu Ala Asn Leu Leu Trp	
5 10 15	

CGG CAT GAG ATG GGC GGG GAC ATT ACC CGC GTG GAG TCA GAG AAC AAG	96
Arg His Glu Met Gly Gly Asp Ile Thr Arg Val Glu Ser Glu Asn Lys	
20 25 30	

GTA GTA ATC CTG GAC TCT TTC GAC CCG CTC CGA GCG GAG GAG GAT GAG	144
Val Val Ile Leu Asp Ser Phe Asp Pro Leu Arg Ala Glu Glu Asp Glu	
35 40 45	

CGG GAA GTG TCC GTC CCG GCG GAG ATC CTG CGG AAA TCC AAG AAA TTC	192
Arg Glu Val Ser Val Pro Ala Glu Ile Leu Arg Lys Ser Lys Lys Phe	
50 55 60	

CCA CCA GCG ATG CCC GCA TGG GCA CGC CCG GAT TAC AAC CCT CCG CTG	240
Pro Pro Ala Met Pro Ala Trp Ala Arg Pro Asp Tyr Asn Pro Pro Leu	
65 70 75 80	
CTG GAG TCC TGG AAG GCC CCG GAC TAC GTC CCT CCA GTG GTA CAT GGG	288
Leu Glu Ser Trp Lys Ala Pro Asp Tyr Val Pro Pro Val Val His Gly	
85 90 95	
TGC CCA CTG CCA CCT ACT AAG ACC CCT CCT ATA CCA CCT CCA GGG AGA	336
Cys Pro Leu Pro Pro Thr Lys Thr Pro Pro Ile Pro Pro Pro Arg Arg	
100 105 110	
AAG AGG ACA GTT GTT CTG ACA GAA TCC ACC GTG TCT TCT GCC CTG GCG	384
Lys Arg Thr Val Val Leu Thr Glu Ser Thr Val Ser Ser Ala Leu Ala	
115 120 125	
GAG CTT GCC ACA AAG GCT TTT GGT AGC TCC GGA CCG TCG GCC GTC GAC	432
Glu Leu Ala Thr Lys Ala Phe Gly Ser Ser Gly Pro Ser Ala Val Asp	
130 135 140	
AGC GGC ACG GCA ACC GCC CCT CCT GAC CAA TCC TCC GAC GAC GGC GGA	480
Ser Gly Thr Ala Thr Ala Pro Pro Asp Gln Ser Ser Asp Asp Gly Gly	
145 150 155 160	
GCA GGA TCT GAC GTT GAG TCG TAT TCC TCC ATG CCC CCC CTT GAG GGG	528
Ala Gly Ser Asp Val Glu Ser Tyr Ser Ser Met Pro Pro Leu Glu Gly	
165 170 175	
GAG CCG GGG GAC CCC GAT CTC AGC GAC GGG TCT TGG TCT ACC GTG AGT	576
Glu Pro Gly Asp Pro Asp Leu Ser Asp Gly Ser Trp Ser Thr Val Ser	
180 185 190	
GAG GAG GCC GGT GAG GAC GTC GTC TGC TGC TCG ATG TCC TAC ACA TGG	624
Glu Glu Ala Gly Glu Asp Val Val Cys Cys Ser Met Ser Tyr Thr Trp	
195 200 205	

ACA GGC GCT CTG ATC ACG CCA TGC GCT GCG GAG GAA AGC AAG CTG CCC	672
Thr Gly Ala Leu Ile Thr Pro Cys Ala Ala Glu Glu Ser Lys Leu Pro	
210 215 220	
ATC AAC GCG TTG AGC AAC TCT TTG CTG CGT CAC CAC AAC ATG GTC TAC	720
Ile Asn Ala Leu Ser Asn Ser Leu Leu Arg His His Asn Met Val Tyr	
225 230 235 240	
GCT ACC ACA TCC CGC AGC GCA AGC CAG CGG CAG AAG AAG GTC ACC TTT	768
Ala Thr Thr Ser Arg Ser Ala Ser Gln Arg Gln Lys Lys Val Thr Phe	
245 250 255	
GAC AGA CTG CAA ATC CTG GAC GAT CAC TAC CAG GAC GTG CTC AAG GAG	816
Asp Arg Leu Gln Ile Leu Asp Asp His Tyr Gln Asp Val Leu Lys Glu	
260 265 270	
ATG AAG GCG AAG GCG TCC ACA GTT AAG GCT AAG CTT CTA TCA GTA GAG	864
Met Lys Ala Lys Ala Ser Thr Val Lys Ala Lys Leu Leu Ser Val Glu	
275 280 285	
GAA GCC TGC AAG CTG ACG CCC CCA CAT TCG GCC AAA TCT AAA TTT GGC	912
Glu Ala Cys Lys Leu Thr Pro Pro His Ser Ala Lys Ser Lys Phe Gly	
290 295 300	
TAT GGG GCA AAG GAC GTC CGG AAC CTA TCC AGC AAG GCC ATT AAC CAC	960
Tyr Gly Ala Lys Asp Val Arg Asn Leu Ser Ser Lys Ala Ile Asn His	
305 310 315 320	
ATC CGC TCC GTG TGG GAG GAC TTG TTG GAA GAC ACT GAA ACA CCA ATT	1008
Ile Arg Ser Val Trp Glu Asp Leu Leu Glu Asp Thr Glu Thr Pro Ile	
325 330 335	
GAC ACC ACC ATC ATG GCA AAA AAT GAG GTT TTC TGC GTC CAA CCA GAG	1056
Asp Thr Thr Ile Met Ala Lys Asn Glu Val Phe Cys Val Gln Pro Glu	
340 345 350	

AGA GGA GGC CGC AAG CCA GCT CGC CTT ATC GTG TTC CCA GAC TTG GGG	1104
Arg Gly Gly Arg Lys Pro Ala Arg Leu Ile Val Phe Pro Asp Leu Gly	
355 360 365	
GTC CGT GTG TGC GAG AAA ATG GCC CTC TAT GAC GTG GTC TCC ACC CTC	1152
Val Arg Val Cys Glu Lys Met Ala Leu Tyr Asp Val Val Ser Thr Leu	
370 375 380	
CCT CAG GCT GTG ATG GGC TCC TCG TAC GGA TTC CAG TAT TCT CCT GGA	1200
Pro Gln Ala Val Met Gly Ser Ser Tyr Gly Phe Gln Tyr Ser Pro Gly	
385 390 395 400	
CAG CGG GTC GAG TTC CTG GTG AAC GCC TGG AAA TCA AAG AAG ACC CCT	1248
Gln Arg Val Glu Phe Leu Val Asn Ala Trp Lys Ser Lys Lys Thr Pro	
405 410 415	
ATG GGC TTT GCA TAT GAC ACC CGC TGT TTT GAC TCA ACA GTC ACT GAG	1296
Met Gly Phe Ala Tyr Asp Thr Arg Cys Phe Asp Ser Thr Val Thr Glu	
420 425 430	
AAT GAC ATC CGT GTA GAG GAG TCA ATT TAT CAA TGT TGT GAC TTG GCC	1344
Asn Asp Ile Arg Val Glu Glu Ser Ile Tyr Gln Cys Cys Asp Leu Ala	
435 440 445	
CCC GAA GCC AGA CAG GCC ATA AGG TCG CTC ACA GAG CGG CTT TAT ATC	1392
Pro Glu Ala Arg Gln Ala Ile Arg Ser Leu Thr Glu Arg Leu Tyr Ile	
450 455 460	
GGG GGT CCC CTG ACT AAT TCA AAA GGG CAG AAC TGC GGC TAT CGC CGG	1440
Gly Gly Pro Leu Thr Asn Ser Lys Gly Gln Asn Cys Gly Tyr Arg Arg	
465 470 475 480	
TGC CGC GCG AGC GGC GTG CTG ACG ACT AGC TGC GGT AAT ACC CTC ACA	1488
Cys Arg Ala Ser Gly Val Leu Thr Thr Ser Cys Gly Asn Thr Leu Thr	
485 490 495	

TGT TAC TTG AAG GCC TCT GCA GCC TGT CGA GCT GCA AAG CTC CAG GAC 1536  
Cys Tyr Leu Lys Ala Ser Ala Ala Cys Arg Ala Ala Lys Leu Gln Asp  
500 505 510

TGC ACG ATG CTC GTG TGC GGA GAC GGC CTT GTC GTT ATC TGT GAG AGC 1584  
Cys Thr Met Leu Val Cys Gly Asp Asp Leu Val Val Ile Cys Glu Ser  
515 520 525

GCG GGA ACC CAG GAG GAC GCG GCG AGC CTA CGA GTC TTC ACG GAG GCT 1632  
Ala Gly Thr Gln Glu Asp Ala Ala Ser Leu Arg Val Phe Thr Glu Ala  
530 535 540

ATG ACT AGG TAC TCT GCC CCC CCC GGG GAC CCG CCC CAA CCA GAA TAC 1680  
Met Thr Arg Tyr Ser Ala Pro Pro Gly Asp Pro Pro Gln Pro Glu Tyr  
545 550 555 560

GAC CTG GAG TTG ATA ACA TCA TGC TCC TCC AAT GTG TCG GTC GCG CAC 1728  
Asp Leu Glu Leu Ile Thr Ser Cys Ser Ser Asn Val Ser Val Ala His  
565 570 575

GAT GCA TCT GGC AAA AGG GTA TAC TAC CTC ACC CGT GAC CCG 1770  
Asp Ala Ser Gly Lys Arg Val Tyr Tyr Leu Thr Arg Asp Pro  
580 585 590



SEQ ID NO:4

SEQUENCE TYPE:Nucleotide with corresponding protein

SEQUENCE LENGTH:1035 BASE PAIRS

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:cDNA to genomic RNA

ORIGINAL SOURCE ORGANISM:human; serum infectious for  
post-transfusional non-A, non-B hepatitis

IMMEDIATE EXPERIMENTAL SOURCE:clone JG3 from cDNA library in lambda  
gt11

FEATURES:

from 1 to 1035 bp portion of the PT-NANBH polyprotein

PROPERTIES:probably encodes viral non-structural proteins

ACA GAA GTG GAT GGG GTG CGG CTG CAC AGG TAC GCT CCG GCG TGC AAA	48
Thr Glu Val Asp Gly Val Arg Leu His Arg Tyr Ala Pro Ala Cys Lys	
5 10 15	

CCT CTC CTA CGG GAG GAG GTC ACA TTC CAG GTC GGG CTC AAC CAA TAC	96
Pro Leu Leu Arg Glu Glu Val Thr Phe Gln Val Gly Leu Asn Gln Tyr	
20 25 30	

CTG GTT GGG TCG CAG CTC CCA TGC GAG CCC GAA CCG GAT GTA GCA GTG	144
Leu Val Gly Ser Gln Leu Pro Cys Glu Pro Glu Pro Asp Val Ala Val	
35 40 45	

CTC ACT TCC ATG CTC ACC GAC CCC TCC CAC ATC ACA GCA GAG ACG GCT	192
Leu Thr Ser Met Leu Thr Asp Pro Ser His Ile Thr Ala Glu Thr Ala	
50 55 60	

CCA CTG CCA CCT ACT AAG ACC CCT CCT ATA CCA CCT CCA CGG AGA AAG 624  
Pro Leu Pro Pro Thr Lys Thr Pro Pro Ile Pro Pro Pro Arg Arg Lys  
195 200 205

AGG ACA GTT GTT CTG ACA GAA TCC ACC GTG TCT TCT GCC CTG GCG GAG 672  
Arg Thr Val Val Leu Thr Glu Ser Thr Val Ser Ser Ala Leu Ala Glu  
210 215 220

CTT GCC ACA AAG GCT TTT GGT AGC TCC GGA CCG TCG GCC GTC GAC AGC 720  
Leu Ala Thr Lys Ala Phe Gly Ser Ser Gly Pro Ser Ala Val Asp Ser  
225 230 235 240

GGC ACG GCA ACC GCC CCT CCT GAC CAA TCC TCC GAC GAC GGC GGA GCA 768  
Gly Thr Ala Thr Ala Pro Pro Asp Gln Ser Ser Asp Asp Gly Gly Ala  
245 250 255

GGA TCT GAC GTT GAG TCG TAT TCC TCC ATG CCC CCC CTT GAG GGG GAG 816  
Gly Ser Asp Val Glu Ser Tyr Ser Ser Met Pro Pro Leu Glu Gly Glu  
260 265 270

CCG GGG GAC CCC GAT CTC AGC GAC GGG TCT TGG TCT ACC GTG AGT GAG 864  
Pro Gly Asp Pro Asp Leu Ser Asp Gly Ser Trp Ser Thr Val Ser Glu  
275 280 285

GAG GCC GGT GAG GAC GTC GTC TGC TGC TCG ATG TCC TAC ACA TGG ACA 912  
Glu Ala Gly Glu Asp Val Val Cys Cys Ser Met Ser Tyr Thr Trp Thr  
290 295 300

GGC GCT CTG ATC ACG CCA TGC GCT GCG GAG GAA AGC AAG CTG CCC ATC 960  
Gly Ala Leu Ile Thr Pro Cys Ala Ala Glu Glu Ser Lys Leu Pro Ile  
305 310 315 320

AAC GCG TTG AGC AAC TCT TTG CTG CGT CAC CAC AAC ATG GTC TAC GCT 1008  
Asn Ala Leu Ser Asn Ser Leu Leu Arg His His Asn Met Val Tyr Ala  
325 330 335

ACC ACA TCC CGC AGC GCA AGC CAG CCG 1035  
Thr Thr Ser Arg Ser Ala Ser Gln Arg  
340 345

SEQ ID NO:5

SEQUENCE TYPE:Nucleotide with corresponding protein

SEQUENCE LENGTH:834 BASE PAIRS

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:cDNA to genomic RNA

ORIGINAL SOURCE ORGANISM:human; serum infectious for  
post-transfusional non-A, non-B hepatitis

IMMEDIATE EXPERIMENTAL SOURCE:clone BR11 from cDNA library in lambda  
gt11

FEATURES:

from 1 to 834 bp portion of the PT-NANBH polyprotein

PROPERTIES:probably encodes viral structural proteins

AGA AAA ACC AAA CGT AAC ACC AAC CTC CGC CCA CAG GAC GTC AGG TTC	48
Arg Lys Thr Lys Arg Asn Thr Asn Leu Arg Pro Gln Asp Val Arg Phe	
5 10 15	
CCG GGC GGT GGT CAG ATC GTT GGT GGA GTT TAC CTG TTG CCG CGC AGG	96
Pro Gly Gly Gly Gln Ile Val Gly Gly Val Tyr Leu Leu Pro Arg Arg	
20 25 30	
GGC CCC AGG TTG GGT GTG CGC GCG ACT AGG AAG ACT TCC GAG CGG TCG	144
Gly Pro Arg Leu Gly Val Arg Ala Thr Arg Lys Thr Ser Glu Arg Ser	
35 40 45	
CAA CCT CGT GGA AGG CGA CAA CCT ATC CCC AAG GCT CGC CAG CCC GAG	192
Gln Pro Arg Gly Arg Arg Gln Pro Ile Pro Lys Ala Arg Gln Pro Glu	
50 55 60	

GGC AGG GCC TGG GCT CAG CCC GGG TAC CCT TGG CCC CTC TAT GGC AAC	240
Gly Arg Ala Trp Ala Gln Pro Gly Tyr Pro Trp Pro Leu Tyr Gly Asn	
65                                      70                                      75                                      80	
GAG GGC ATG GGG TGG GCA GGA TGG CTC CTG TCA CCC CGT GGC TCC CGG	288
Glu Gly Met Gly Trp Ala Gly Trp Leu Leu Ser Pro Arg Gly Ser Arg	
85                                      90                                      95	
CCT AGT TGG GGC CCC ACT GAC CCC CGG CGT AGG TCG CGT AAT TTG GGT	336
Pro Ser Trp Gly Pro Thr Asp Pro Arg Arg Arg Ser Arg Asn Leu Gly	
100                                      105                                      110	
AAA GTC ATC GAT ACC CTC ACA TGC GGC TTC GCC GAC TCT CAT GGG GTA	384
Lys Val Ile Asp Thr Leu Thr Cys Gly Phe Ala Asp Ser His Gly Val	
115                                      120                                      125	
CAT TCC GCT CGT CGG CGC TCC CTT AGG GGC GCT GCC AGG GCC CTG GCG	432
His Ser Ala Arg Arg Arg Ser Leu Arg Gly Ala Ala Arg Ala Leu Ala	
130                                      135                                      140	
CAT GGC GTC CGG GTT CTG GAG GAC GGC GTG AAC TAT GCA ACA GGC AAT	480
His Gly Val Arg Val Leu Glu Asp Gly Val Asn Tyr Ala Thr Gly Asn	
145                                      150                                      155                                      160	
TTA CCC GGT TGC TCT TTC TCT ATC TTC CTC TTG GCT TTG CTG TCC TGT	528
Leu Pro Gly Cys Ser Phe Ser Ile Phe Leu Leu Ala Leu Leu Ser Cys	
165                                      170                                      175	
TTG ACC ATT CCA GCT TCC GCT TAT GAA GTG CGC AAC GTG TCC GGG ATC	576
Leu Thr Ile Pro Ala Ser Ala Tyr Glu Val Arg Asn Val Ser Gly Ile	
180                                      185                                      190	
TAC CAT GTC ACG AAC GAT TGC TCC AAC TCA AGC ATC GTG TAC GAG ACA	624
Tyr His Val Thr Asn Asp Cys Ser Asn Ser Ser Ile Val Tyr Glu Thr	
195                                      200                                      205	

GCG GAC ATG ATC ATG CAC ACC CCC GGG TGT GTG CCC TGT GTC CGG GAG	672
Ala Asp Met Ile Met His Thr Pro Gly Cys Val Pro Cys Val Arg Glu	
210 215 220	
 GGT AAT TCC TCC CGC TGC TGG GTA GCG CTC ACT CCC ACG CTC GCG GCC	720
Gly Asn Ser Ser Arg Cys Trp Val Ala Leu Thr Pro Thr Leu Ala Ala	
225 230 235 240	
 AAG GAC GCC AGC ATC CCC ACT GCG ACA ATA CGA CGC CAC GTC GAT TTG	768
Lys Asp Ala Ser Ile Pro Thr Ala Thr Ile Arg Arg His Val Asp Leu	
245 250 255	
 CTC GTT GGG GCG GCT GCC TTC TCG TCC GCT ATG TAC GTG GGG GAT CTC	816
Leu Val Gly Ala Ala Ala Phe Ser Ser Ala Met Tyr Val Gly Asp Leu	
260 265 270	
 TGC GGA TCT GTT TTC CCG	834
Cys Gly Ser Val Phe Pro	
275	

SEQ ID NO:6  
SEQUENCE TYPE:Nucleotide  
SEQUENCE LENGTH:31 BASES

STRANDEDNESS:single  
TOPOLOGY:linear  
MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:bacteriophage lambda gt11  
IMMEDIATE EXPERIMENTAL SOURCE:Oligonucleotide synthesiser; oligo d75

FEATURES:

from 4 to 9 bases BamH1 site  
from 10 to 31 bases homologous to upstream portion of lacZ gene  
flanking the EcoR1 site in bacteriophage lambda gt11  
from 26 to 31 bases EcoR1 site

PROPERTIES:primes DNA synthesis from the phage vector into cDNA  
inserted at the EcoR1 site and introduces a BamH1 site suitable for  
subsequent cloning into expression vectors.

TAAGGATCCC CCGTCAGTAT CGGCGGAATT C

31

SEQ ID NO:7

SEQUENCE TYPE:Nucleotide

SEQUENCE LENGTH:30 BASES

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:bacteriophage lambda gt11

IMMEDIATE EXPERIMENTAL SOURCE:Oligonucleotide synthesiser; oligo d76

FEATURES:

from 4 to 9 bases BamH1 site

from 10 to 30 bases homologous to downstream portion of lacZ gene

flanking the EcoR1 site in bacteriophage lambda gt11

PROPERTIES:primes DNA synthesis from the phage vector into cDNA  
inserted at the EcoR1 site and introduces a BamH1 site suitable for  
subsequent cloning into expression vectors.

TATGGATCCG TAGCGACCGG CGCTCAGCTG

30



SEQ ID NO:8  
SEQUENCE TYPE:Nucleotide  
SEQUENCE LENGTH:19 BASES

STRANDEDNESS:single  
TOPOLOGY:linear  
MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:human; serum infectious for  
post-transfusional non-A, non-B hepatitis  
IMMEDIATE EXPERIMENTAL SOURCE:oligonucleotide synthesiser; oligo d94

FEATURES:  
from 1 to 19 bases homologous to bases 914 to 932 of the sense strand  
of JG2 (SEQ ID NO : 3)

PROPERTIES:primes DNA synthesis on the negative strand of PT-NANBH  
genomic RNA/DNA.

ATGGGGCAAA GGACGTCCG

19

SEQ ID NO:9

SEQUENCE TYPE:Nucleotide

SEQUENCE LENGTH:24 BASES

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:human; serum infectious for  
post-transfusional non-A, non-B hepatitis

IMMEDIATE EXPERIMENTAL SOURCE:oligonucleotide synthesiser; oligo d95

FEATURES:

from 1 to 24 bases homologous to bases 1620 to 1643 of the anti-sense  
strand of JG2 (SEQ ID NO : 3)

PROPERTIES:primes DNA synthesis on the positive strand of PT-NANBH  
genomic RNA/DNA.

TACCTAGTCA TAGCCTCCGT GAAG

24

SEQ ID NO:10  
SEQUENCE TYPE:Nucleotide  
SEQUENCE LENGTH:17 BASES

STRANDEDNESS:single  
TOPOLOGY:linear  
MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:human; serum infectious for  
post-transfusional non-A, non-B hepatitis  
IMMEDIATE EXPERIMENTAL SOURCE:oligonucleotide synthesiser; oligo N1

FEATURES:

from 1 to 17 bases homologous to bases 1033 to 1049 of the sense  
strand of JG2 (SEQ ID NO : 3)

PROPERTIES:primes DNA synthesis on the negative strand of PT-NANBH  
genomic RNA/DNA.

GAGGTTTCT GCGTCCA

17

SEQ ID NO:11

SEQUENCE TYPE:Nucleotide

SEQUENCE LENGTH:17 BASES

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:human; serum infectious for  
post-transfusional non-A, non-B hepatitis

IMMEDIATE EXPERIMENTAL SOURCE:oligonucleotide synthesiser; oligo N2

FEATURES:

from 1 to 17 bases homologous to bases 1421 to 1437 of the anti-sense  
strand of JG2 (SEQ ID NO : 3)

PROPERTIES:primes DNA synthesis on the positive strand of PT-NANBH  
genomic RNA/DNA.

GCGATAGCCG CAGTTCT

17

SEQ ID NO:12  
SEQUENCE TYPE:Nucleotide  
SEQUENCE LENGTH:22 BASES

STRANDEDNESS:single  
TOPOLOGY:linear  
MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:human; serum infectious for  
post-transfusional non-A, non-B hepatitis  
IMMEDIATE EXPERIMENTAL SOURCE:oligonucleotide synthesiser; oligo dl64

FEATURES:

from 1 to 22 bases homologous to bases 10 to 31 of the sequence in Fig  
2 of Okamoto et al, Japan. J. Exp. Med., 1990, 60 167-177, base 22  
changed from A to T to introduce Bgl2 recognition site  
from 8 to 13 bases Bgl2 recognition site

PROPERTIES:primes DNA synthesis on the negative strand of PT-NANBH  
genomic RNA/DNA and introduces a Bgl2 site.

CCACCATAGA TCTCTCCCCT GT

22

SEQ ID NO:13  
SEQUENCE TYPE:Nucleotide  
SEQUENCE LENGTH:30 BASES

STRANDEDNESS:single  
TOPOLOGY:linear  
MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:human; serum infectious for  
post-transfusional non-A, non-B hepatitis  
IMMEDIATE EXPERIMENTAL SOURCE:oligonucleotide synthesiser; oligo d137

FEATURES:

from 1 to 30 bases homologous to bases 154 to 183 of the negative  
strand of BR11 (SEQ ID NO : 5); bases 174, 177 and 178 modified to  
introduce an EcoR1 recognition site  
from 5 to 10 bases EcoR1 recognition site

PROPERTIES:primes DNA synthesis on the positive strand of PT-NANBH  
genomic RNA/DNA and introduces an EcoR1 site for cloning

GCGAGAATTC GGGATAGGTT GTCGCCTTCC

30

SEQ ID NO:14  
SEQUENCE TYPE:Nucleotide  
SEQUENCE LENGTH:27 BASES

STRANDEDNESS:single  
TOPOLOGY:linear  
MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:human; serum infectious for  
post-transfusional non-A, non-B hepatitis  
IMMEDIATE EXPERIMENTAL SOURCE:oligonucleotide synthesiser; oligo dl36

FEATURES:

from 1 to 27 bases homologous to bases 672 to 698 of the positive  
strand of BR11 (SEQ ID NO : 5); base 675 changed to G to introduce an  
EcoR1 recognition site  
from 4 to 9 bases EcoR1 recognition site

PROPERTIES:primes DNA synthesis on the negative strand of PT-NANBH  
genomic RNA/DNA and introduces an EcoR1 site for cloning

GGCGAATTCC TCCCGCTGCT GGGTAGC

27

SEQ ID NO:15

SEQUENCE TYPE:Nucleotide

SEQUENCE LENGTH:28 BASES

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:chimpanzee; serum infectious for  
post-transfusional non-A, non-B hepatitis

IMMEDIATE EXPERIMENTAL SOURCE:oligonucleotide synthesiser; oligo d155

FEATURES:

from 1 to 28 bases homologous to bases 462 to 489 of the negative  
strand of figure 47, European Patent Application 88310922.5; bases 483  
and 485 changed to introduce an EcoR1 recognition site  
from 5 to 10 bases EcoR1 recognition site

PROPERTIES:primes DNA synthesis on the positive strand of PT-NANBH  
genomic RNA/DNA and introduces an EcoR1 site for cloning

ACGGGAATTC GACCAGGCAC CTGGGTGT

28



SEQ ID NO:16

SEQUENCE TYPE:Nucleotide

SEQUENCE LENGTH:23 BASES

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:chimpanzee; serum infectious for  
post-transfusional non-A, non-B hepatitis

IMMEDIATE EXPERIMENTAL SOURCE:oligonucleotide synthesiser; oligo d156

FEATURES:

from 1 to 23 bases homologous to bases 3315 to 3337 of the positive  
strand of figure 47, European Patent Application 88310922.5; base 3323  
changed to C to introduce an EcoR1 recognition site  
from 4 to 9 bases EcoR1 recognition site

PROPERTIES:primes DNA synthesis on the negative strand of PT-NANBH  
genomic RNA/DNA and introduces an EcoR1 site for cloning

CTTGAATTCT GGGAGGGCGT CTT

23

SEQ ID NO:17

SEQUENCE TYPE:Nucleotide

SEQUENCE LENGTH:29 BASES

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:human; serum infectious for  
post-transfusional non-A, non-B hepatitis

IMMEDIATE EXPERIMENTAL SOURCE:oligonucleotide synthesiser; oligo d92

FEATURES:

from 1 to 29 bases homologous to bases 36 to 64 of the negative strand  
of JG2 (SEQ ID NO : 3); bases 57, 58 and 60 changed to introduce an  
EcoR1 recognition site  
from 5 to 10 bases EcoR1 recognition site

PROPERTIES:primes DNA synthesis on the positive strand of PT-NANBH  
genomic RNA/DNA and introduces an EcoR1 site for cloning

CGCCGAATTC ATGCCGCCAC AGGAGGTTG

29

SEQ ID NO:18

SEQUENCE TYPE:Nucleotide with corresponding protein

SEQUENCE LENGTH:504 BASE PAIRS

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:cDNA to genomic RNA

ORIGINAL SOURCE ORGANISM:human; serum infectious for  
post-transfusional non-A, non-B hepatitis

IMMEDIATE EXPERIMENTAL SOURCE:clone 164/137

FEATURES:

from 308 to 504 bp start of the PT-NANBH polyprotein

PROPERTIES:probably encodes viral structural proteins

GATCACTCCC CTGTGAGGAA CTACTGTCTT CACGCAGAAA GCGTCTAGCC ATGGCGTTAG 60  
TATGAGTGTC GTGCAGCCTC CAGGACCCCC CCTCCCGGGA GAGCCATAGT GGTCTGCGGA 120  
ACCGGTGAGT ACACCGGAAT TGCCAGGACG ACCGGGTCCT TTCTTGGATT AACCCGCTCA 180  
ATGCCTGGAG ATTTGGGCGT GCGCCCGCAA GACTGCTAGC CGAGTAGTGT TGGGTCGCCA 240  
AAGGCCTTGT GGTACTGCCT GATAGGGTGC TTGCGAGTGC CCCGGGAGGT CTCGTAGACC 300  
GTGCACC ATG AGC ACG AAT CCT AAA CCT CAA AGA AAA ACC AAA CGT AAC 349

Met Ser Thr Asn Pro Lys Pro Gln Arg Lys Thr Lys Arg Asn

5

10

ACC AAC CGC CGC CCA CAG GAC GTC AAG TTC CCG GGC GGT GGT CAG ATC 397  
Thr Asn Pro Arg Pro Gln Asp Val Lys Phe Pro Gly Gly Gly Gln Ile  
15 20 25 30

GTT GGT GGA GTT TAC CTG TTG CCG CGC AGG GGC CCC AGG TTG GGT GTG 445  
Val Gly Gly Val Tyr Leu Leu Pro Arg Arg Gly Pro Arg Leu Gly Val  
35 40 45

CGC GCG ACT AGG AAG ACT TCC GAG CGG TCG CAA CCT CGT GGA AGG CGA 493  
Arg Ala Thr Arg Lys Thr Ser Glu Arg Ser Gln Pro Arg Gly Arg Arg  
50 55 60

CAA CCT ATC CC 504  
Gln Pro Ile Pro  
65

SEQ ID NO:19

SEQUENCE TYPE:Nucleotide with corresponding protein

SEQUENCE LENGTH:1107 BASE PAIRS

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:cDNA to genomic RNA

ORIGINAL SOURCE ORGANISM:human; serum infectious for  
post-transfusional non-A, non-B hepatitis  
IMMEDIATE EXPERIMENTAL SOURCE:clone 136/155

FEATURES:

from 1 to 1107 bp portion of the PT-NANBH polyprotein

PROPERTIES:probably encodes viral structural proteins

TCC TCC CGC TGC TGG GTA GCG CTC ACT CCC ACG CTC GCG GCC AAG GAC	48
Ser Ser Arg Cys Trp Val Ala Leu Thr Pro Thr Leu Ala Ala Lys Asp	
5 10 15	

GCC AGC ATC CCC ACT GCG ACA ATA CGA CGC CAC GTC GAT TTG CTC GTT	96
Ala Ser Ile Pro Thr Ala Thr Ile Arg Arg His Val Asp Leu Leu Val	
20 25 30	

GGG GCG GCT GCC TTC TGC TCC GCT ATG TAC GTG GGG GAT CTC TGC GGA	144
Gly Ala Ala Ala Phe Cys Ser Ala Met Tyr Val Gly Asp Leu Cys Gly	
35 40 45	

TCT GTT TTC CTC GTC TCT CAG CTG TTC ACC TTC TCG CCT CGC CGA CAT	192
Ser Val Phe Leu Val Ser Gln Leu Phe Thr Phe Ser Pro Arg Arg His	
50 55 60	

GGT CAC CGC ATG GCT TGG GAT ATG ATG ATG AAC TGG TCA CCT ACA GCA 288  
Gly His Arg Met Ala Trp Asp Met Met Met Asn Trp Ser Pro Thr Ala  
85 90 95

GCC CTA GTG GTA TCG CAG CTA CTC CGG ATC CCA CAA GCT GTC GTG GAC 336  
Ala Leu Val Val Ser Gln Leu Leu Arg Ile Pro Gln Ala Val Val Asp  
100 105 110

ATG GTG GCG GGG GCC CAC TGG GGA GTC CTG GCG GGC CTT GCC TAC TAT 384  
Met Val Ala Gly Ala His Trp Gly Val Leu Ala Gly Leu Ala Tyr Tyr  
115 120 125

TCC ATG GTG GGG AAC TGG GCT AAG GTC TTG GTT GTG ATG CTA CTC TTT 432  
Ser Met Val Gly Asn Trp Ala Lys Val Leu Val Val Met Leu Leu Phe  
130 135 140

GCC GGC GTT GAC GGG GAA CCT TAC ACG ACA GGG GGG ACA CAC GGC CGC 480  
Ala Gly Val Asp Gly Glu Pro Tyr Thr Thr Gly Gly Thr His Gly Arg  
145 150 155 160

GCC GCC CAC GGG CTT ACA TCC CTC TTC ACA CCT GGG CCG GCT CAG AAA 528  
Ala Ala His Gly Leu Thr Ser Leu Phe Thr Pro Gly Pro Ala Gln Lys  
165 170 175

ATC CAG CTT GTA AAC ACC AAC GGC AGC TGG CAC ATC AAC AGA ACT GCC 576  
Ile Gln Leu Val Asn Thr Asn Gly Ser Trp His Ile Asn Arg Thr Ala  
180 185 190

TTG AAC TGC AAT GAC TCC CTC CAA ACT GGG TTC CTT GCC GCG CTG TTC 624  
Leu Asn Cys Asn Asp Ser Leu Gln Thr Gly Phe Leu Ala Ala Leu Phe  
195 200 205

TAC ACG CAC AGG TTC AAT GCG TCC GGA TGC TCA GAG CGC ATG GCC AGC	672
Tyr Thr His Arg Phe Asn Ala Ser Gly Cys Ser Glu Arg Met Ala Ser	
210 215 220	
TGC CGC CCC ATT GAC CAG TTC GAT CAG GGG TGG GGT CCC ATC ACT TAT	720
Cys Arg Pro Ile Asp Gln Phe Asp Gln Gly Trp Gly Pro Ile Thr Tyr	
225 230 235 240	
AAT GAG TCC CAC GGC TTG GAC CAG AGG CCC TAT TGC TGG CAC TAC GCA	768
Asn Glu Ser His Gly Leu Asp Gln Arg Pro Tyr Cys Trp His Tyr Ala	
245 250 255	
CCT CAA CCG TGT GGT ATC GTG CCC GCG TTG CAG GTG TGT GGC CCA GTG	816
Pro Gln Pro Cys Gly Ile Val Pro Ala Leu Gln Val Cys Gly Pro Val	
260 265 270	
TAC TGT TTC ACT CCA AGC CCT GTT GTG GTG GGG ACG ACC GAT CGT TTC	864
Tyr Cys Phe Thr Pro Ser Pro Val Val Val Gly Thr Thr Asp Arg Phe	
275 280 285	
GGC GCC CCT ACG TAC AGA TGG GGT GAG AAT GAG ACG GAC GTG CTG CTT	912
Gly Ala Pro Thr Tyr Arg Trp Gly Glu Asn Glu Thr Asp Val Leu Leu	
290 295 300	
CTC AAC AAC ACG CCG CCG CCA CCG GGC AAC TGG TTC GGC TGT ACA TGG	960
Leu Asn Asn Thr Arg Pro Pro Arg Gly Asn Trp Phe Gly Cys Thr Trp	
305 310 315 320	
ATG AAT AGC ACC GGG TTC ACC AAG ACG TGT GGG GGC CCC CCG TGC AAC	1008
Met Asn Ser Thr Gly Phe Thr Lys Thr Cys Gly Gly Pro Pro Cys Asn	
325 330 335	
ATC GGG GGG GTC GGC AAC AAC ACT TTG ATC TGC CCC ACG GAC TGC TTC	1056
Ile Gly Gly Val Gly Asn Asn Thr Leu Ile Cys Pro Thr Asp Cys Phe	
340 345 350	

CGG AAG CAT CCC GAG GCC ACT TAC ACC AAA TGC GGT TCG GGG CCT TGG 1104  
Arg Lys His Pro Glu Ala Thr Tyr Thr Lys Cys Gly Ser Gly Pro Trp  
355 360 365

TTG  
1107  
Leu



SEQ ID NO:20

SEQUENCE TYPE:Nucleotide with corresponding protein

SEQUENCE LENGTH:2043 BASE PAIRS

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:cDNA to genomic RNA

ORIGINAL SOURCE ORGANISM:human; serum infectious for  
post-transfusional non-A, non-B hepatitis  
IMMEDIATE EXPERIMENTAL SOURCE:clone 156/92

# FEATURES:

from 1 to 2043 bp portion of the PT-NANBH polyprotein

PROPERTIES:probably encodes viral non-structural proteins

TGG GAG GGC GTC TTC ACA GGC CTC ACC CAC GTG GAT GCC CAC TTC CTG	48
Trp Glu Gly Val Phe Thr Gly Leu Thr His Val Asp Ala His Phe Leu	
5 10 15	
TCC CAA ACA AAG CAG GCA GGA GAC AAC TTC CCC TAC CTG GTG GCG TAC	96
Ser Gln Thr Lys Gln Ala Gly Asp Asn Phe Pro Tyr Leu Val Ala Tyr	
20 25 30	
CAG GCT ACT GTG TGC GCT AGG GCC CAG GCC CCA CCT CCA TCA TGG GAT	144
Gln Ala Thr Val Cys Ala Arg Ala Gln Ala Pro Pro Pro Ser Trp Asp	
35 40 45	
CAA ATG TGG AAG TGT CTC ATA CGG CTA AAG CCT ACT CTG CGC GGG CCA	192
Gln Met Trp Lys Cys Leu Ile Arg Leu Lys Pro Thr Leu Arg Gly Pro	
50 55 60	

ACA CAC CCC ATA ACC AAA TTC ATC ATG GCA TGC ATG TCA GCC GAC CTG 288  
Thr His Pro Ile Thr Lys Phe Ile Met Ala Cys Met Ser Ala Asp Leu  
85 90 95

CTG GCT GCG TAT TGC TTG ACA ACA GGC AGC GTG GTC ATT GTG GGT AGG 384  
Leu Ala Ala Tyr Cys Leu Thr Thr Gly Ser Val Val Ile Val Gly Arg  
115 120 125

ATC ATC TTG TCC GGG CGG CCG GCT ATT GTT CCC GAC AGG GAA GTC CTC 432  
Ile Ile Leu Ser Gly Arg Pro Ala Ile Val Pro Asp Arg Glu Val Leu  
130 135 140

TAC CAG GAG TTC GAT GAG ATG GAA GAG TGC GCG TCG CAC CTC CCT TAC 480  
Tyr Gln Glu Phe Asp Glu Met Glu Glu Cys Ala Ser His Leu Pro Tyr  
145 150 155 160

ATC GAG CAG GGA ATG CAG CTC GCC GAG CAG TTC AAG CAA AAA GCG CTC 528  
Ile Glu Gln Gly Met Gln Leu Ala Glu Gln Phe Lys Gln Lys Ala Leu  
165 170 175

GGG TTG CTG CAG ACA GCC ACC AAG CAA GCG GAG GCC GCT GCT CCC GTG 576  
Gly Leu Leu Gln Thr Ala Thr Lys Gln Ala Glu Ala Ala Ala Pro Val  
180 185 190

GTG GAG TCC AAG TGG CGA GCC CTT GAG ACC TTC TGG GCG AAA CAC ATG 624  
Val Glu Ser Lys Trp Arg Ala Leu Glu Thr Phe Trp Ala Lys His Met  
195 200 205

TGG AAC TTC ATC AGC GGG ATA CAG TAC TTA GCA GGC TTG TCC ACT CTG	672
Trp Asn Phe Ile Ser Gly Ile Gln Tyr Leu Ala Gly Leu Ser Thr Leu	
210 215 220	
 CCT GGG AAT CCC GCG ATT GCA TCA CTG ATG GCG TTC ACA GCC TCT GTC	720
Pro Gly Asn Pro Ala Ile Ala Ser Leu Met Ala Phe Thr Ala Ser Val	
225 230 235 240	
 ACT AGC CCG CTC ACC ACC CAA TCT ACC CTC CTG CTT AAC ATC CTG GGG	768
Thr Ser Pro Leu Thr Thr Gln Ser Thr Leu Leu Leu Asn Ile Leu Gly	
245 250 255	
 GGA TGG GTA GCC GCC CAA CTC GCT CCC CCC AGT GCT GCT TCA GCT TTC	816
Gly Trp Val Ala Ala Gln Leu Ala Pro Pro Ser Ala Ala Ser Ala Phe	
260 265 270	
 GTA GGC GCC GGC ATT GCT GGT GCG GCT GTT GGC AGC ATA GGC CTT GGG	864
Val Gly Ala Gly Ile Ala Gly Ala Ala Val Gly Ser Ile Gly Leu Gly	
275 280 285	
 AAG GTG CTT GTG GAC ATC TTG GCG GGC TAT GGA GCA GGA GTG GCA GGC	912
Lys Val Leu Val Asp Ile Leu Ala Gly Tyr Gly Ala Gly Val Ala Gly	
290 295 300	
 GCG CTC GTG GCC TTT AAG GTC ATG AGC GGC GAA ATG CCC TCC ACC GAG	960
Ala Leu Val Ala Phe Lys Val Met Ser Gly Glu Met Pro Ser Thr Glu	
305 310 315 320	
 GAC CTG GTT AAC TTA CTC CCT GCC ATC CTC TCT CCT GGT GCC CTG GTC	1008
Asp Leu Val Asn Leu Leu Pro Ala Ile Leu Ser Pro Gly Ala Leu Val	
325 330 335	
 GTC GGG GTC GTG TGC GCA GCG ATA CTG CGT CGG CAC GTG GGT CCA GGG	1056
Val Gly Val Val Cys Ala Ala Ile Leu Arg Arg His Val Gly Pro Gly	
340 345 350	

GAG GGG GCT GTG CAG TGG ATG AAC CGG CTG ATA GCG TTC GCC TCG CGG	1104
Glu Gly Ala Val Gln Trp Met Asn Arg Leu Ile Ala Phe Ala Ser Arg	
355 360 365	
GGT AAC CAT GTT TCC CCC ACG CAC TAT GTG CCA GAG AGC GAC GCC GCA	1152
Gly Asn His Val Ser Pro Thr His Tyr Val Pro Glu Ser Asp Ala Ala	
370 375 380	
GCA CGT GTC ACT CAG ATC CTC TCC GAC CTT ACT ATC ACC CAA CTG TTG	1200
Ala Arg Val Thr Gln Ile Leu Ser Asp Leu Thr Ile Thr Gln Leu Leu	
385 390 395 400	
AAG AGG CTC CAC CAG TGG ATT AAC GAG GAC TGC TCC ACG CCC TGC TCC	1248
Lys Arg Leu His Gln Trp Ile Asn Glu Asp Cys Ser Thr Pro Cys Ser	
405 410 415	
GGC TCG TGG CTA AGG GAT GTT TGG GAC TGG ATA TGC ACA GTT TTG GCT	1296
Gly Ser Trp Leu Arg Asp Val Trp Asp Trp Ile Cys Thr Val Leu Ala	
420 425 430	
GAC TTC AAG ACC TGG CTC CAG TCC AAG CTC CTG CCG CGA TTA CCG GGA	1344
Asp Phe Lys Thr Trp Leu Gln Ser Lys Leu Leu Pro Arg Leu Pro Gly	
435 440 445	
GTC CCC TTT TTC TCA TGC CAA CGT GGG TAC AAG GGG GTC TGG CGG GGA	1392
Val Pro Phe Phe Ser Cys Gln Arg Gly Tyr Lys Gly Val Trp Arg Gly	
450 455 460	
GAC GGC ATC ATG CAG ACC ACC TGC TCA TGT GGA GCA CAG ATC ACC GGA	1440
Asp Gly Ile Met Gln Thr Thr Cys Ser Cys Gly Ala Gln Ile Thr Gly	
465 470 475 480	
CAT GTC AAA AAC GGT TCC ATG AGG ATC GTT GGG CCT AAG ACC TGT AGT	1488
His Val Lys Asn Gly Ser Met Arg Ile Val Gly Pro Lys Thr Cys Ser	
485 490 495	

AAC ATG TGG CAT GGA ACA TTC CCC ATC AAC GCA TAC ACC ACG GGC CCC 1536  
Asn Met Trp His Gly Thr Phe Pro Ile Asn Ala Tyr Thr Thr Gly Pro  
500 505 510

TGC ACG CCC TCC CCA GCG CCA AAC TAT TCC AGG GCG CTG TGG CGG GTG 1584  
Cys Thr Pro Ser Pro Ala Pro Asn Tyr Ser Arg Ala Leu Trp Arg Val  
515 520 525

GCT GCT GAG GAG TAC GTG GAG GTT ACG CGG GTG GGG GAT TTC CAC TAC 1632  
Ala Ala Glu Glu Tyr Val Glu Val Thr Arg Val Gly Asp Phe His Tyr  
530 535 540

GTG ACG AGC ATG ACC ACT GAC AAC GTA AAA TGC CCG TGC CAG GTT CCA 1680  
Val Thr Ser Met Thr Thr Asp Asn Val Lys Cys Pro Cys Gln Val Pro  
545 550 555 560

GCC CCC GAA TTC TTC ACA GAA GTG GAT GGG GTG CCG CTG CAC AGG TAC 1728  
Ala Pro Glu Phe Phe Thr Glu Val Asp Gly Val Arg Leu His Arg Tyr  
565 570 575

GCT CCG GCG TGC AAA CCT CTC CTA CGG GAG GAG GTC ACA TTC CAG GTC 1776  
Ala Pro Ala Cys Lys Pro Leu Leu Arg Glu Glu Val Thr Phe Gln Val  
580 585 590

GGG CTC AAC CAA TAC CTG GTT GGG TCG CAG CTC CCA TGC GAG CCC GAA 1824  
Gly Leu Asn Gln Tyr Leu Val Gly Ser Gln Leu Pro Cys Glu Pro Glu  
595 600 605

CCG GAT GTA GCA GTG CTC ACT TCC ATG CTC ACC GAC CCC TCC CAC ATC 1872  
Pro Asp Val Ala Val Leu Thr Ser Met Leu Thr Asp Pro Ser His Ile  
610 615 620

ACA GCA GAG ACG GCT AAG CGC AGG CTG GCC AGG GGG TCT CCC CCC TCC 1920  
Thr Ala Glu Thr Ala Lys Arg Arg Leu Ala Arg Gly Ser Pro Pro Ser  
625 630 635 640

TTG GCC AGC TCT TCA GCT AGC CAG TTG TCT GCG CCT TCC TCG AAG GCG 1968  
 Leu Ala Ser Ser Ser Ala Ser Gln Leu Ser Ala Pro Ser Ser Lys Ala

645

650

655

ACA TAC ATT ACC CAA AAT GAC TTC CCA GAC GCT GAC CTC ATC GAG GCC 2016  
 Thr Tyr Ile Thr Gln Asn Asp Phe Pro Asp Ala Asp Leu Ile Glu Ala

660

665

670

AAC CTC CTG TGG CGG CAT GAG ATG GGC  
 Asn Leu Leu Trp Arg His Glu Met Gly

2043

675

680

SEQ ID NO:21

SEQUENCE TYPE:Nucleotide with corresponding protein

SEQUENCE LENGTH:2116 BASE PAIRS

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:cDNA to genomic RNA

ORIGINAL SOURCE ORGANISM:human; serum infectious for  
post-transfusional non-A, non-B hepatitis

IMMEDIATE EXPERIMENTAL SOURCE:contig formed by cDNA clones from 5' end  
of the genome

FEATURES:

from 308 to 2116 bp start of the PT-NANBH polyprotein

PROPERTIES:viral structural and non-structural proteins

GATCACTCCC CTGTGAGGAA CTACTGTCTT CACGCAGAAA GCGTCTAGCC ATGGCGTTAG 60  
TATGAGTGTC GTGCAGCCTC CAGGACCCCC CCTCCCGGGA GAGCCATAGT GGTCTGCGGA 120  
ACCGGTGAGT ACACCGGAAT TGCCAGGACG ACCGGGTCTT TTCTTGATT AACCCGCTCA 180  
ATGCCCTGAG ATTTGGGCGT GCGCCCGCAA GACTGCTAGC CGAGTAGTGT TGGGTCGCGA 240  
AAGGCCTTGT GGTACTGCCT GATAGGGTGC TTGCGAGTGC CCCGGGAGGT CTCGTAGACC 300  
GTGCACC ATG AGC ACG AAT CCT AAA CCT CAA AGA AAA ACC AAA CGT AAC 349

Met Ser Thr Asn Pro Lys Pro Gln Arg Lys Thr Lys Arg Asn

5

10

ACC AAC CGC CGC CCA CAG GAC GTC AAG TTC CCG GGC GGT GGT CAG ATC 397  
Thr Asn Pro Arg Pro Gln Asp Val Lys Phe Pro Gly Gly Gly Gln Ile  
15 20 25 30

GTT GGT GGA GTT TAC CTG TTG CCG CGC AGG GGC CCC AGG TTG GGT GTG 445  
Val Gly Gly Val Tyr Leu Leu Pro Arg Arg Gly Pro Arg Leu Gly Val  
35 40 45

CGC GCG ACT AGG AAG ACT TCC GAG CGG TCG CAA CCT CGT GGA AGG CGA	493
Arg Ala Thr Arg Lys Thr Ser Glu Arg Ser Gln Pro Arg Gly Arg Arg	
50 55 60	
CAA CCT ATC CCC AAG GCT CGC CAG CCC GAG GGC AGG GCC TGG GCT CAG	541
Gln Pro Ile Pro Lys Ala Arg Gln Pro Glu Gly Arg Ala Trp Ala Gln	
65 70 75	
CCC GGG TAC CCT TGG CCC CTC TAT GGC AAC GAG GGC ATG GGG TGG GCA	589
Pro Gly Tyr Pro Trp Pro Leu Tyr Gly Asn Glu Gly Met Gly Trp Ala	
80 85 90	
GGA TGG CTC CTG TCA CCC CGT GGC TCC CGG CCT AGT TGG GGC CCC ACT	637
Gly Trp Leu Leu Ser Pro Arg Gly Ser Arg Pro Ser Trp Gly Pro Thr	
100 105 110 115	
GAC CCC CGG CGT AGG TCG CGT AAT TTG GGT AAA GTC ATC GAT ACC CTC	685
Asp Pro Arg Arg Arg Ser Arg Asn Leu Gly Lys Val Ile Asp Thr Leu	
120 125 130	
ACA TGC GGC TTC GCC GAC CTC ATG GGG TAC ATT CCG CTC GTC GGC GCT	733
Thr Cys Gly Phe Ala Asp Leu Met Gly Tyr Ile Pro Leu Val Gly Ala	
135 140 145	
CCC TTA GGG GGC GCT GCC AGG GCC CTG GCG CAT GGC GTC CGG GTT CTG	781
Pro Leu Gly Gly Ala Ala Arg Ala Leu Ala His Gly Val Arg Val Leu	
150 155 160	
GAG GAC GGC GTG AAC TAT GCA ACA GGG AAT TTA CCC GGT TGC TCT TTC	829
Glu Asp Gly Val Asn Tyr Ala Thr Gly Asn Leu Pro Gly Cys Ser Phe	
165 170 175	
TCT ATC TTC CTC TTG GCT TTG CTG TCC TGT TTG ACC ATT CCA GCT TCC	877
Ser Ile Phe Leu Leu Ala Leu Leu Ser Cys Leu Thr Ile Pro Ala Ser	
180 185 190 195	



GCT TAT GAA GTG CGC AAC GTG TCC GGG ATC TAC CAT GTC ACG AAC GAT 925  
Ala Tyr Glu Val Arg Asn Val Ser Gly Ile Tyr His Val Thr Asn Asp  
200 205 210

TGC TCC AAC TCA AGC ATC GTG TAC GAG ACA GCG GAC ATG ATC ATG CAC 973  
Cys Ser Asn Ser Ser Ile Val Tyr Glu Thr Ala Asp Met Ile Met His  
215 220 225

ACC CCC GGG TGT GTG CCC TGT GTC CGG GAG GGT AAT TCC TCC CGC TGC 1021  
Thr Pro Gly Cys Val Pro Cys Val Arg Glu Gly Asn Ser Ser Arg Cys  
230 235 240

TGG GTA GCG CTC ACT CCC ACG CTC GCG GCC AAG GAC GCC AGC ATC CCC 1069  
Trp Val Ala Leu Thr Pro Thr Leu Ala Ala Lys Asp Ala Ser Ile Pro  
245 250 255

ACT GCG ACA ATA CGA CGC CAC GTC GAT TTG CTC GTT GGG GCG GCT GCC 1117  
Thr Ala Thr Ile Arg Arg His Val Asp Leu Leu Val Gly Ala Ala Ala  
260 265 270 275

TTC TGC TCC GCT ATG TAC GTG GGG GAT CTC TGC GGA TCT GTT TTC CTC 1165  
Phe Cys Ser Ala Met Tyr Val Gly Asp Leu Cys Gly Ser Val Phe Leu  
280 285 290

GTC TCT CAG CTG TTC ACC TTC TCG CCT CGC CGA CAT CAG ACG GTA CAG 1213  
Val Ser Gln Leu Phe Thr Phe Ser Pro Arg Arg His Gln Thr Val Gln  
295 300 305

GAC TGC AAT TGT TCA ATC TAT CCC GGC CAC GTA TCA GGT CAC CGC ATG 1261  
Asp Cys Asn Cys Ser Ile Tyr Pro Gly His Val Ser Gly His Arg Met  
310 315 320

GCT TGG GAT ATG ATG ATG AAC TGG TCA CCT ACA GCA GCC CTA GTG GTA 1309  
Ala Trp Asp Met Met Met Asn Trp Ser Pro Thr Ala Ala Leu Val Val  
325 330 335

TCG CAG CTA CTC CGG ATC CCA CAA GCT GTC GTG GAC ATG GTG GCG GGG 1357  
Ser Gln Leu Leu Arg Ile Pro Gln Ala Val Val Asp Met Val Ala Gly  
340 345 350 355

GCC CAC TGG GGA GTC CTG GCG GGC CTT GCC TAC TAT TCC ATG GTG GGG 1405  
Ala His Trp Gly Val Leu Ala Gly Leu Ala Tyr Tyr Ser Met Val Gly  
360 365 370

AAC TGG GCT AAG GTC TTG GTT GTG ATG CTA CTC TTT GCC GGC GTT GAC 1453  
Asn Trp Ala Lys Val Leu Val Val Met Leu Leu Phe Ala Gly Val Asp  
375 380 385

GGG GAA CCT TAC ACG ACA GGG GGG ACA CAC GGC CGC GCC GCC CAC GGG 1501  
Gly Glu Pro Tyr Thr Thr Gly Gly Thr His Gly Arg Ala Ala His Gly  
390 395 400

CTT ACA TCC CTC TTC ACA CCT GGG CCG GCT CAG AAA ATC CAG CTT GTA 1549  
Leu Thr Ser Leu Phe Thr Pro Gly Pro Ala Gln Lys Ile Gln Leu Val  
405 410 415

AAC ACC AAC GGC AGC TGG CAC ATC AAC AGA ACT GCC TTG AAC TGC AAT 1597  
Asn Thr Asn Gly Ser Trp His Ile Asn Arg Thr Ala Leu Asn Cys Asn  
420 425 430 435

GAC TCC CTC CAA ACT GGG TTC CTT GCC GCG CTG TTC TAC ACG CAC AGG 1645  
Asp Ser Leu Gln Thr Gly Phe Leu Ala Ala Leu Phe Tyr Thr His Arg  
440 445 450

TTC AAT GCG TCC GGA TGC TCA GAG CGC ATG GCC AGC TGC CGC CCC ATT 1693  
Phe Asn Ala Ser Gly Cys Ser Glu Arg Met Ala Ser Cys Arg Pro Ile  
455 460 465

GAC CAG TTC GAT CAG GGG TGG GGT CCC ATC ACT TAT AAT GAG TCC CAC 1741  
Asp Gln Phe Asp Gln Gly Trp Gly Pro Ile Thr Tyr Asn Glu Ser His  
470 475 480

GGC TTG GAC CAG AGG CCC TAT TGC TGG CAC TAC GCA CCT CAA CCG TGT	1789
Gly Leu Asp Gln Arg Pro Tyr Cys Trp His Tyr Ala Pro Gln Pro Cys	
485 490 495	
GGT ATC GTG CCC GCG TTG CAG GTG TGT GGC CCA GTG TAC TGT TTC ACT	1837
Gly Ile Val Pro Ala Leu Gln Val Cys Gly Pro Val Tyr Cys Phe Thr	
500 505 510 515	
CCA AGC CCT GTT GTG GTG GGG ACG ACC GAT CGT TTC GGC GCC CCT ACG	1885
Pro Ser Pro Val Val Val Gly Thr Thr Asp Arg Phe Gly Ala Pro Thr	
520 525 530	
TAC AGA TGG GGT GAG AAT GAG ACG GAC GTG CTG CTT CTC AAC AAC ACG	1933
Tyr Arg Trp Gly Glu Asn Glu Thr Asp Val Leu Leu Leu Asn Asn Thr	
535 540 545	
CGG CCG CCA CGG GGC AAC TGG TTC GGC TGT ACA TGG ATG AAT AGC ACC	1981
Arg Pro Pro Arg Gly Asn Trp Phe Gly Cys Thr Trp Met Asn Ser Thr	
550 555 560	
GGG TTC ACC AAG ACG TGT GGG GGC CCC CCG TGC AAC ATC GGG GGG GTC	2029
Gly Phe Thr Lys Thr Cys Gly Gly Pro Pro Cys Asn Ile Gly Gly Val	
565 570 575	
GGC AAC AAC ACT TTG ATC TGC CCC ACG GAC TGC TTC CGG AAG CAT CCC	2077
Gly Asn Asn Thr Leu Ile Cys Pro Thr Asp Cys Phe Arg Lys His Pro	
580 585 590 595	
GAG GCC ACT TAC ACC AAA TGC GGT TCG GGG CCT TGG TTG	2116
Glu Ala Thr Tyr Thr Lys Cys Gly Ser Gly Pro Trp Leu	
600 605	

SEQ ID NO:22

SEQUENCE TYPE:Nucleotide with corresponding protein

SEQUENCE LENGTH:3750 BASE PAIRS

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:cDNA to genomic RNA

ORIGINAL SOURCE ORGANISM:human; serum infectious for  
post-transfusional non-A, non-B hepatitis

IMMEDIATE EXPERIMENTAL SOURCE:contig formed by cDNA clones from 3' end  
of the genome

# FEATURES:

from 1 to 3750 bp portion of the PT-NANBH polyprotein

PROPERTIES:viral non-structural proteins

TGG GAG GGC GTC TTC ACA GGC CTC ACC CAC GTG GAT GCC CAC TTC CTG	48
Trp Glu Gly Val Phe Thr Gly Leu Thr His Val Asp Ala His Phe Leu	
5 10 15	

TCC CAA ACA AAG CAG GCA GGA GAC AAC TTC CCC TAC CTG GTG GCG TAC	96
Ser Gln Thr Lys Gln Ala Gly Asp Asn Phe Pro Tyr Leu Val Ala Tyr	
20 25 30	

CAG GCT ACT GTG TGC GCT AGG GCC CAG GCC CCA CCT CCA TCA TGG GAT	144
Gln Ala Thr Val Cys Ala Arg Ala Gln Ala Pro Pro Pro Ser Trp Asp	
35 40 45	

CAA ATG TGG AAG TGT CTC ATA CGG CTA AAG CCT ACT CTG CGC GGG CCA	192
Gln Met Trp Lys Cys Leu Ile Arg Leu Lys Pro Thr Leu Arg Gly Pro	
50 55 60	

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TGG AAC TTC ATC AGC GGG ATA CAG TAC TTA GCA GGC TTG TCC ACT CTC	672
Trp Asn Phe Ile Ser Gly Ile Gln Tyr Leu Ala Gly Leu Ser Thr Leu	
210 215 220	
CCT GGG AAT CCC GCG ATT GCA TCA CTG ATG GCG TTC ACA GCC TCT GTC	720
Pro Gly Asn Pro Ala Ile Ala Ser Leu Met Ala Phe Thr Ala Ser Val	
225 230 235 240	
ACT AGC CCG CTC ACC ACC CAA TCT ACC CTC CTG CTT AAC ATC CTG GGG	768
Thr Ser Pro Leu Thr Thr Gln Ser Thr Leu Leu Leu Asn Ile Leu Gly	
245 250 255	
GGA TGG GTA GCC GCC CAA CTC GCT CCC CCC AGT GCT GCT TCA GCT TTC	816
Gly Trp Val Ala Ala Gln Leu Ala Pro Pro Ser Ala Ala Ser Ala Phe	
260 265 270	
GTA GGC GCC GGC ATT GCT GGT GCG GCT GTT GGC AGC ATA GGC CTT GGG	864
Val Gly Ala Gly Ile Ala Gly Ala Ala Val Gly Ser Ile Gly Leu Gly	
275 280 285	
AAG GTG CTT GTG GAC ATC TTG GCG GGC TAT GGA GCA GGA GTG GCA GGC	912
Lys Val Leu Val Asp Ile Leu Ala Gly Tyr Gly Ala Gly Val Ala Gly	
290 295 300	
GCG CTC GTG GCC TTT AAG GTC ATG AGC GGC GAA ATG CCC TCC ACC GAG	960
Ala Leu Val Ala Phe Lys Val Met Ser Gly Glu Met Pro Ser Thr Glu	
305 310 315 320	
GAC CTG GTT AAC TTA CTC CCT GCC ATC CTC TCT CCT GGT GCC CTG GTC	1008
Asp Leu Val Asn Leu Leu Pro Ala Ile Leu Ser Pro Gly Ala Leu Val	
325 330 335	
GTC GGG GTC GTG TGC GCA GCG ATA CTG CGT CGG CAC GTG GGT CCA GGG	1056
Val Gly Val Val Cys Ala Ala Ile Leu Arg Arg His Val Gly Pro Gly	
340 345 350	

GAG GGG GCT GTG CAG TGG ATG AAC CGG CTG ATA GCG TTC GCC TCG CGG	1104
Glu Gly Ala Val Gln Trp Met Asn Arg Leu Ile Ala Phe Ala Ser Arg	
355 360 365	
GGT AAC CAT GTT TCC CCC ACG CAC TAT GTG CCA GAG AGC GAC GCC GCA	1152
Gly Asn His Val Ser Pro Thr His Tyr Val Pro Glu Ser Asp Ala Ala	
370 375 380	
GCA CGT GTC ACT CAG ATC CTC TCC GAC CTT ACT ATC ACC CAA CTG TTG	1200
Ala Arg Val Thr Gln Ile Leu Ser Asp Leu Thr Ile Thr Gln Leu Leu	
385 390 395 400	
AAG AGG CTC CAC CAG TGG ATT AAC GAG GAC TGC TCC ACG CCC TGC TCC	1248
Lys Arg Leu His Gln Trp Ile Asn Glu Asp Cys Ser Thr Pro Cys Ser	
405 410 415	
GGC TCG TGG CTA AGG GAT GTT TGG GAC TGG ATA TGC ACA GTT TTG GCT	1296
Gly Ser Trp Leu Arg Asp Val Trp Asp Trp Ile Cys Thr Val Leu Ala	
420 425 430	
GAC TTC AAG ACC TGG CTC CAG TCC AAG CTC CTG CCG CGA TTA CCG GGA	1344
Asp Phe Lys Thr Trp Leu Gln Ser Lys Leu Leu Pro Arg Leu Pro Gly	
435 440 445	
GTC CCC TTT TTC TCA TGC CAA CGT GGG TAC AAG GGG GTC TGG CGG GGA	1392
Val Pro Phe Phe Ser Cys Gln Arg Gly Tyr Lys Gly Val Trp Arg Gly	
450 455 460	
GAC GGC ATC ATG CAG ACC ACC TGC TCA TGT GGA GCA CAG ATC ACC GGA	1440
Asp Gly Ile Met Gln Thr Thr Cys Ser Cys Gly Ala Gln Ile Thr Gly	
465 470 475 480	
CAT GTC AAA AAC GGT TCC ATG AGG ATC GTT GGG CCT AAG ACC TGT AGT	1488
His Val Lys Asn Gly Ser Met Arg Ile Val Gly Pro Lys Thr Cys Ser	
485 490 495	

AAC ATG TGG CAT GGA ACA TTC CCC ATC AAC GCA TAC ACC ACG GGC CCC 1536  
Asn Met Trp His Gly Thr Phe Pro Ile Asn Ala Tyr Thr Thr Gly Pro  
500 505 510

TGC ACG CCC TCC CCA GCG CCA AAC TAT TCC AGG GCG CTG TGG CGG GTG 1584  
Cys Thr Pro Ser Pro Ala Pro Asn Tyr Ser Arg Ala Leu Trp Arg Val  
515 520 525

GCT GCT GAG GAG TAC GTG GAG GTT ACG CGG GTG GGG GAT TTC CAC TAC 1632  
Ala Ala Glu Glu Tyr Val Glu Val Thr Arg Val Gly Asp Phe His Tyr  
530 535 540

GTG ACG AGC ATG ACC ACT GAC AAC GTA AAA TGC CCG TGC CAG GTT CCA 1680  
Val Thr Ser Met Thr Thr Asp Asn Val Lys Cys Pro Cys Gln Val Pro  
545 550 555 560

GCC CCC GAA TTC TTC ACA GAA GTG GAT GGG GTG CGG CTG CAC AGG TAC 1728  
Ala Pro Glu Phe Phe Thr Glu Val Asp Gly Val Arg Leu His Arg Tyr  
565 570 575

GCT CCG GCG TGC AAA CCT CTC CTA CGG GAG GAG GTC ACA TTC CAG GTC 1776  
Ala Pro Ala Cys Lys Pro Leu Leu Arg Glu Glu Val Thr Phe Gln Val  
580 585 590

GGG CTC AAC CAA TAC CTG GTT GGG TCG CAG CTC CCA TGC GAG CCC GAA 1824  
Gly Leu Asn Gln Tyr Leu Val Gly Ser Gln Leu Pro Cys Glu Pro Glu  
595 600 605

CCG GAT GTA GCA GTG CTC ACT TCC ATG CTC ACC GAC CCC TCC CAC ATC 1872  
Pro Asp Val Ala Val Leu Thr Ser Met Leu Thr Asp Pro Ser His Ile  
610 615 620

ACA GCA GAG ACG GCT AAG CGC AGG CTG GCC AGG GGG TCT CCC CCC TCC 1920  
Thr Ala Glu Thr Ala Lys Arg Arg Leu Ala Arg Gly Ser Pro Pro Ser  
625 630 635 640



TTG GCC AGC TCT TCA GCT AGC CAG TTG TCT GCG CCT TCC TCG AAG GCG	1968
Leu Ala Ser Ser Ser Ala Ser Gln Leu Ser Ala Pro Ser Ser Lys Ala	
645 650 655	
ACA TAC ATT ACC CAA AAT GAC TTC CCA GAC GCT GAC CTC ATC GAG GCC	2016
Thr Tyr Ile Thr Gln Asn Asp Phe Pro Asp Ala Asp Leu Ile Glu Ala	
660 665 670	
AAC CTC CTG TGG CGG CAT GAG ATG GGC GGG GAC ATT ACC CGC GTG GAG	2064
Asn Leu Leu Trp Arg His Glu Met Gly Gly Asp Ile Thr Arg Val Glu	
675 680 685	
TCA GAG AAC AAG GTA GTA ATC CTG GAC TCT TTC GAC CCG CTC CGA GCG	2112
Ser Glu Asn Lys Val Val Ile Leu Asp Ser Phe Asp Pro Leu Arg Ala	
690 695 700	
GAG GAG GAT GAG CGG GAA GTG TCC GTC CCG GCG GAG ATC CTG CGG AAA	2160
Glu Glu Asp Glu Arg Glu Val Ser Val Pro Ala Glu Ile Leu Arg Lys	
705 710 715 720	
TCC AAG AAA TTC CCA CCA GCG ATG CCC GCA TGG GCA CGC CCG GAT TAC	2208
Ser Lys Lys Phe Pro Pro Ala Met Pro Ala Trp Ala Arg Pro Asp Tyr	
725 730 735	
AAC CCT CCG CTG CTG GAG TCC TGG AAG GCC CCG GAC TAC GTC CCT CCA	2256
Asn Pro Pro Leu Leu Glu Ser Trp Lys Ala Pro Asp Tyr Val Pro Pro	
740 745 750	
GTG GTA CAT GGG TGC CCA CTG CCA CCT ACT AAG ACC CCT CCT ATA CCA	2304
Val Val His Gly Cys Pro Leu Pro Pro Thr Lys Thr Pro Pro Ile Pro	
755 760 765	
CCT CCA CGG AGG AAG AGG ACA GTT GTT CTG ACA GAA TCC ACC GTG TCT	2352
Pro Pro Arg Arg Lys Arg Thr Val Val Leu Thr Glu Ser Thr Val Ser	
770 775 780	

TCT GCC CTG GCG GAG CTT GCC ACA AAG GCT TTC GGT AGC TCC GAA CCG	2400
Ser Ala Leu Ala Glu Leu Ala Thr Lys Ala Phe Gly Ser Ser Glu Pro	
785                                      790                                      795                                      800	
TCG GCC GTC GAC AGC GGC ACG GCA ACC GCC CCT CCT GAC CAA CCC TCC	2448
Ser Ala Val Asp Ser Gly Thr Ala Thr Ala Pro Pro Asp Gln Pro Ser	
805                                      810                                      815	
GAC GAC GGC GGA GCA GGA TCT GAC GTT GAG TCG TAT TCC TCC ATG CCC	2496
Asp Asp Gly Gly Ala Gly Ser Asp Val Glu Ser Tyr Ser Ser Met Pro	
820                                      825                                      830	
CCC CTT GAG GGG GAG CCG GGG GAC CCC GAT CTC AGC GAC GGG TCT TGG	2544
Pro Leu Glu Gly Glu Pro Gly Asp Pro Asp Leu Ser Asp Gly Ser Trp	
835                                      840                                      845	
TCT ACC GTG AGT GAG GAG GCC GGT GAG GAC GTC GTC TGC TGC TCG ATG	2592
Ser Thr Val Ser Glu Glu Ala Gly Glu Asp Val Val Cys Cys Ser Met	
850                                      855                                      860	
TCC TAC ACA TGG ACA GGC GCT CTG ATC ACG CCA TGC GCT GCG GAG GAA	2640
Ser Tyr Thr Trp Thr Gly Ala Leu Ile Thr Pro Cys Ala Ala Glu Glu	
865                                      870                                      875                                      880	
AGC AAG CTG CCC ATC AAC GCG TTG AGC AAC TCT TTG CTG CGT CAC CAC	2688
Ser Lys Leu Pro Ile Asn Ala Leu Ser Asn Ser Leu Leu Arg His His	
885                                      890                                      895	
AAC ATG GTC TAC GCT ACC ACA TCC CGC AGC GCA AGC CAG CGG CAG AAG	2736
Asn Met Val Tyr Ala Thr Thr Ser Arg Ser Ala Ser Gln Arg Gln Lys	
900                                      905                                      910	
AAG GTC ACC TTT GAC AGA CTG CAA ATC CTG GAC GAT CAC TAC CAG GAC	2784
Lys Val Thr Phe Asp Arg Leu Gln Ile Leu Asp Asp His Tyr Gln Asp	
915                                      920                                      925	

GTG CTC AAG GAG ATG AAG GCG AAG GCG TCC ACA GTT AAG GCT AAG CTT	2832
Val Leu Lys Glu Met Lys Ala Lys Ala Ser Thr Val Lys Ala Lys Leu	
930 935 940	
CTA TCA GTA GAG GAA GCC TGC AAG CTG ACG CCC CCA CAT TCG GCC AAA	2880
Leu Ser Val Glu Glu Ala Cys Lys Leu Thr Pro Pro His Ser Ala Lys	
945 950 955 960	
TCT AAA TTT GGC TAT GGG GCA AAG GAC GTC CGG AAC CTA TCC AGC AAG	2928
Ser Lys Phe Gly Tyr Gly Ala Lys Asp Val Arg Asn Leu Ser Ser Lys	
965 970 975	
GCC ATT AAC CAC ATC CGC TCC GTG TGG GAG GAC TTG TTG GAA GAC ACT	2976
Ala Ile Asn His Ile Arg Ser Val Trp Glu Asp Leu Leu Glu Asp Thr	
980 985 990	
GAA ACA CCA ATT GAC ACC ACC ATC ATG GCA AAA AAT GAG GTT TTC TGC	3024
Glu Thr Pro Ile Asp Thr Thr Ile Met Ala Lys Asn Glu Val Phe Cys	
995 1000 1005	
GTC CAA CCA GAG AGA GGA GGC CGC AAG CCA GCT CGC CTT ATC GTG TTC	3072
Val Gln Pro Glu Arg Gly Gly Arg Lys Pro Ala Arg Leu Ile Val Phe	
1010 1015 1020	
CCA GAC TTG GGG GTC CGT GTG TGC GAG AAA ATG GCC CTC TAT GAC GTG	3120
Pro Asp Leu Gly Val Arg Val Cys Glu Lys Met Ala Leu Tyr Asp Val	
1025 1030 1035 1040	
GTC TCC ACC CTC CCT CAG GCT GTG ATG GGC TCC TCG TAC GGA TTC CAG	3168
Val Ser Thr Leu Pro Gln Ala Val Met Gly Ser Ser Tyr Gly Phe Gln	
1045 1050 1055	
TAT TCT CCT GGA CAG CGG GTC GAG TTC CTG GTG AAC GCC TGG AAA TCA	3216
Tyr Ser Pro Gly Gln Arg Val Glu Phe Leu Val Asn Ala Trp Lys Ser	
1060 1065 1070	

AAG AAG ACC CCT ATG GGC TTT GCA TAT GAC ACC CGC TGT TTT GAC TCA 3264  
Lys Lys Thr Pro Met Gly Phe Ala Tyr Asp Thr Arg Cys Phe Asp Ser  
1075 1080 1085

AGA GTC ACT GAG AAT GAC ATC CGT GTA GAG GAG TCA ATT TAT CAA TGT 3312  
Thr Val Thr Glu Asn Asp Ile Arg Val Glu Glu Ser Ile Tyr Gln Cys  
1090 1095 1100

TGT GAC TTG GCC CCC GAA GCC AGA CAG GCC ATA AGG TCG CTC ACA GAG 3360  
Cys Asp Leu Ala Pro Glu Ala Arg Gln Ala Ile Arg Ser Leu Thr Glu  
1105 1110 1115 1120

CGG CTT TAT ATC GGG GGT CCC CTG ACT AAT TCA AAA GGG CAG AAC TGC 3408  
Arg Leu Tyr Ile Gly Gly Pro Leu Thr Asn Ser Lys Gly Gln Asn Cys  
1125 1130 1135

GGC TAT CGC CGG TGC CGC GCG AGC GGC GTG CTG ACG ACT AGC TGC GGT 3456  
Gly Tyr Arg Arg Cys Arg Ala Ser Gly Val Leu Thr Thr Ser Cys Gly  
1140 1145 1150

AAT ACC CTC ACA TGT TAC TTG AAG GCC TCT GCA GCC TGT CGA GCT GCA 3504  
Asn Thr Leu Thr Cys Tyr Leu Lys Ala Ser Ala Ala Cys Arg Ala Ala  
1155 1160 1165

AAG CTC CAG GAC TGC ACG ATG CTC GTG TGC GGA GAC GGC CTT GTC GTT 3552  
Lys Leu Gln Asp Cys Thr Met Leu Val Cys Gly Asp Asp Leu Val Val  
1170 1175 1180

ATC TGT GAG AGC GCG GGA ACC CAG GAG GAC GCG GCG AGC CTA CGA GTC 3600  
Ile Cys Glu Ser Ala Gly Thr Gln Glu Asp Ala Ala Ser Leu Arg Val  
1185 1190 1195 1200

TTC ACG GAG GCT ATG ACT AGG TAC TCT GCC CCC CCC GGG GAC CCG CCC 3648  
Phe Thr Glu Ala Met Thr Arg Tyr Ser Ala Pro Pro Gly Asp Pro Pro  
1205 1210 1215

CAA CCA GAA TAC GAC CTG GAG TTG ATA ACA TCA TGC TCC TCC AAT GTG 3696  
Gln Pro Glu Tyr Asp Leu Glu Leu Ile Thr Ser Cys Ser Ser Asn Val  
1220 1225 1230

TCG GTC GCG CAC GAT GCA TCT GGC AAA ACG GTA TAC TAC CTC ACC CGT 3744  
Ser Val Ala His Asp Ala Ser Gly Lys Arg Val Tyr Tyr Leu Thr Arg  
1235 1240 1245

GAC CCG 3750  
Asp Pro  
1250

SEQ ID NO:23

SEQUENCE TYPE:Nucleotide

SEQUENCE LENGTH:23 BASES

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:baculovirus Autographa californica Nuclear  
Polyhedrosis virus (AcNPV)

IMMEDIATE EXPERIMENTAL SOURCE:Oligonucleotide synthesiser; oligo d24

FEATURES:

from 1 to 23 bases homologous to portion of AcNPV polyhedrin gene  
downstream of the BamH1 cloning site in pAc360 and similar vectors

PROPERTIES:primes DNA synthesis from baculovirus transfer vector  
sequences which flank DNA inserted at the BamH1 site.

CGGGTTTAAC ATTACGGATT TCC

23

SEQ ID NO:24  
SEQUENCE TYPE:Nucleotide  
SEQUENCE LENGTH:31 BASES

STRANDEDNESS:single  
TOPOLOGY:linear  
MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:baculovirus Autographa californica Nuclear  
Polyhedrosis virus (AcNPV)  
IMMEDIATE EXPERIMENTAL SOURCE:Oligonucleotide synthesiser; oligo d126

FEATURES:

from 1 to 31 bases homologous to the upstream junction sequences  
produced when cDNA amplified by d75 (SEQ ID 5) is cloned into the  
BamH1 cloning site in pAc360 and similar vectors; mismatches at bases  
13 and 14 introduce a Pst1 site  
from 1 to 10 bases homologous to region of BamH1 site in pAc360 and  
similar vectors  
from 4 to 9 bases BamH1 site  
from 12 to 17 bases Pst1 site

PROPERTIES:primes DNA synthesis at the junction of baculovirus  
transfer vector sequences and sequences previously amplified by oligo  
d75; introduces a Pst1 recognition site for subsequent cloning work

TAAGGATCCC CCT GCA GTA TCG GCG GAA TTC  
Ser Ala Val Ser Ala Glu Phe

31

SEQ ID NO:25

SEQUENCE TYPE:Nucleotide

SEQUENCE LENGTH:45 BASES

STRANDEDNESS:single

TOPOLOGY:linear

MOLECULE TYPE:synthetic DNA

ORIGINAL SOURCE ORGANISM:N/A

IMMEDIATE EXPERIMENTAL SOURCE:Oligonucleotide synthesiser; oligo d132

FEATURES:

from 5 to 10 bases PstI recognition site

from 13 to 27 bases linker coding for five Lys residues

from 28 to 45 bases homologous to bases 4 to 21 of BR11 (SEQ ID 7)

PROPERTIES:primes DNA synthesis at the 5' end of BR11 and introduces a synthetic sequence which codes for five lysines as well as a PstI recognition site for subsequent cloning work

CTGCCTGCA GTA AAG AAG AAG AAG AAG AAA ACC AAA CGT AAC ACC A 45

Val Lys Lys Lys Lys Lys Lys Thr Lys Arg Asn Leu

5

10



Claims:-

1. A PT-NANBH viral polypeptide comprising an antigen having an amino acid sequence that is at least 90% homologous with the amino acid sequence set forth in SEQ ID NO: 3,4,5,18,19,20,21 or 22, or an antigenic fragment thereof.
2. A PT-NANBH viral polypeptide according to claim 1, in which the amino acid sequence is at least 90% homologous with the amino acid sequence set forth in SEQ ID NO: 3, 4, or 5, or is an antigenic fragment thereof.
3. A PT-NANBH viral polypeptide according to claim 2, in which the amino acid sequence is at least 90% homologous with the amino acid sequence set forth in SEQ ID NO: 3 or 4, or is an antigenic fragment thereof.
4. A PT-NANBH viral polypeptide according to claim 2, in which the amino acid sequence is at least 90% homologous with the amino acid sequence set forth in SEQ ID NO: 5, or is an antigenic fragment thereof.
5. A PT-NANBH viral polypeptide according to any one of the preceding claims, in which the amino acid sequence is at least 95% homologous with the amino acid sequence set forth in the SEQ ID NO., or is an antigenic fragment thereof.
6. A PT-NANBH viral polypeptide according to claim 5, in which the amino acid sequence is at least 98% homologous with the amino acid sequence set forth in the SEQ ID NO., or is an antigenic fragment thereof.
7. A PT-NANBH viral polypeptide comprising an antigen from the structural coding region of the viral genome and an antigen from the non-structural coding region of the viral genome.

8. A PT-NANBH viral polypeptide according to claim 7, in which the antigen from the structural coding region has an amino acid sequence that is at least 90% homologous with the amino acid sequence set forth in SEQ ID NO : 5, or an antigenic fragment thereof, and the antigen from the non-structural coding region has an amino acid sequence that is at least 90% homologous with the amino acid sequence set forth in SEQ ID NO : 3 or 4, or an antigenic fragment thereof.
9. A DNA sequence encoding a PT-NANBH viral polypeptide according to any one of claims 1 to 8.
10. A DNA sequence according to claim 9 as set forth in SEQ ID NO: 3, 4, 5, 18, 19, 20, 21 or 22.
11. An expression vector containing a DNA sequence, according to either of claims 9 and 10, and being capable in an appropriate host of expressing the DNA sequence to produce a PT-NANBH viral polypeptide.
12. An host cell transformed with an expression vector according to claim 11.
13. A process for preparing PT-NANBH viral polypeptide which comprises cloning, or synthesising a DNA sequence encoding PT-NANBH viral polypeptide according to any one of claims 1 to 8, inserting the DNA sequence into an expression vector such that it is capable in an appropriate host of being expressed, transforming an host cell with the expression vector, culturing the transformed host cell, and isolating the viral polypeptide.
14. A polyclonal or monoclonal antibody against a PT-NANBH viral polypeptide, according to any one of claims 1 to 6.

15. A method for the detection of PT-NANBH viral nucleic acid, which comprises:

- i) hybridising viral RNA present in a test sample, or cDNA synthesised from such RNA, with a DNA sequence corresponding to SEQ 1D NO: 3, 4, 5, 18, 19, 20, 21 or 22, and screening the resulting nucleic acid hybrids to identify any PT-NANBH viral nucleic acid; or
- ii) synthesising cDNA from viral RNA present in a test sample, amplifying a preselected DNA sequence corresponding to a subsequence of the SEQ 1D NO: 3, 4, 5, 18, 19, 20, 21 or 22, and identifying the preselected DNA sequence.

16. A test kit for the detection of PT-NANBH viral nucleic acid, which comprises:

- i) a pair of oligonucleotide primers one of which corresponds to a portion of the nucleotide sequence of SEQ 1D NO: 3,4,5,18,19,20,21 or 22 and the other of which is located to the 3' side of the first and corresponds to a portion of the complementary sequence, the pair defining between them a preselected DNA sequence;
- ii) a reverse transcriptase enzyme for the synthesis of cDNA from test sample RNA upstream of the primer corresponding to the complementary nucleotide sequence of SEQ 1D NO: 3,4,5,18,19,20,21 or 22;
- iii) an enzyme capable of amplifying the preselected DNA sequence; and optionally
- iv) washing solutions and reaction buffers.

17. A method for the detection of PT-NANBH viral antigen or viral antibody, which comprises contacting a test sample with a PT-NANBH viral polypeptide according to any of claims 1 to 8, or a polyclonal or monoclonal antibody according to claim 14, and determining whether there is any antigen-antibody binding contained within the test sample.
18. A test kit for the detection of PT-NANBH viral antigen or viral antibody, which comprises a PT-NANBH viral polypeptide according to any of claims 1 to 8, or a polyclonal or monoclonal antibody according to claim 14, and means for determining whether there is any antigen-antibody binding contained within the test sample.
19. A vaccine formulation which comprises a PT-NANBH viral polypeptide according to any of claims 1 to 8, in association with a pharmaceutically acceptable carrier.
20. A method for inducing immunity in man to PT-NANBH, which comprises the administration of an effective amount of a vaccine formulation according to claim 19.

MJS/AC/12th December, 1990.